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October 2003
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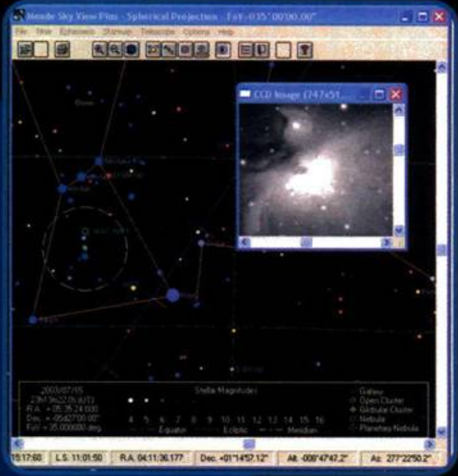

Planetarium program showing Orion region.

Mars and the Moon images taken with altazimuth mounted 8" LX90's by first-time users of the LPI camera and software.

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*(below, left to right)* 8" Model SC-8 Schmidt-Cassegrain; 5" Model AR-5 and 6" Model AR-6 Achromatic Refractors.

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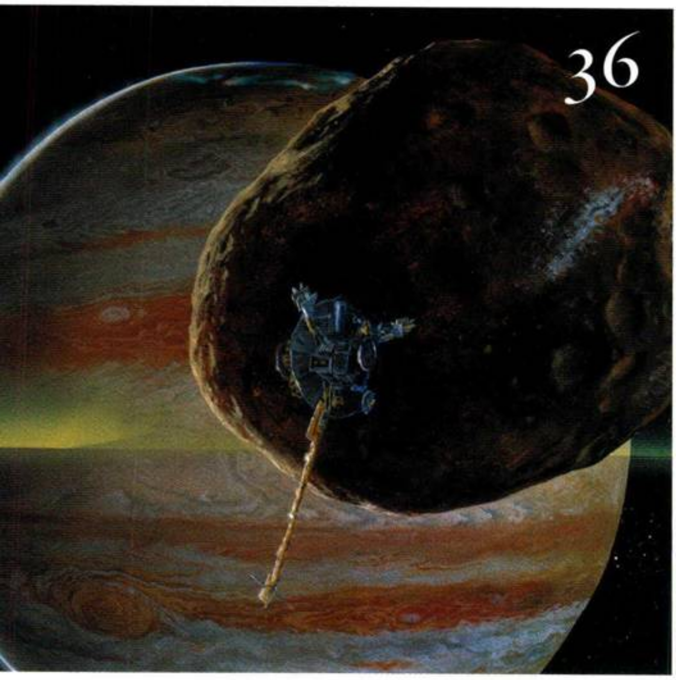

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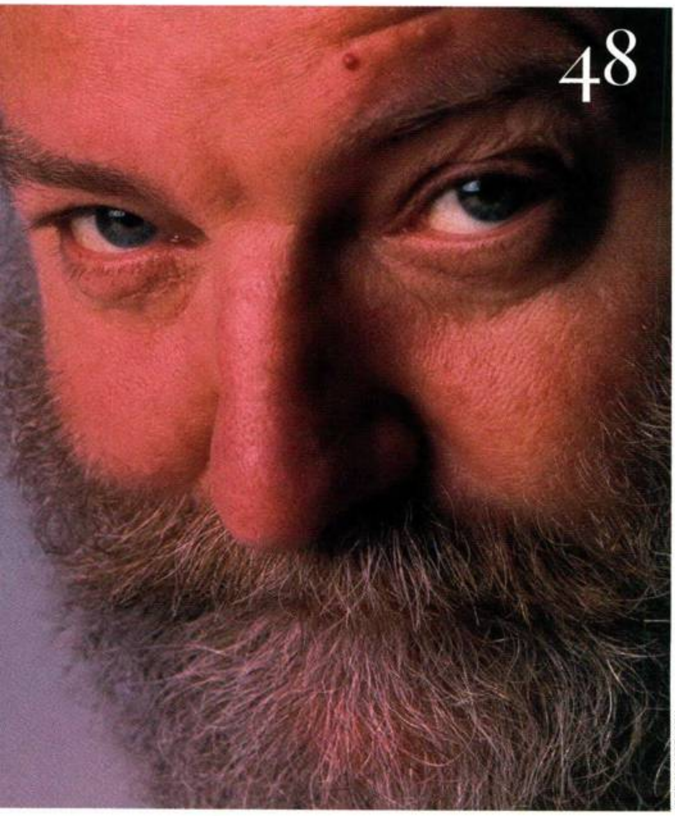

JEFF CHRISTENSEN

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Astronomy
Crashing into JUPITER

**ON THE COVER**
The Galileo spacecraft has spent eight years orbiting giant Jupiter, studying the planet's roiling atmosphere and the Great Red Spot, an immense storm nearly twice the size of Earth, in exquisite detail. It also scrutinized all of Jupiter's big moons, including volcanic Io (upper left). The mission ends this September when the craft plunges into Jupiter. GALILEO AND IO: NASA/JPL; JUPITER: NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

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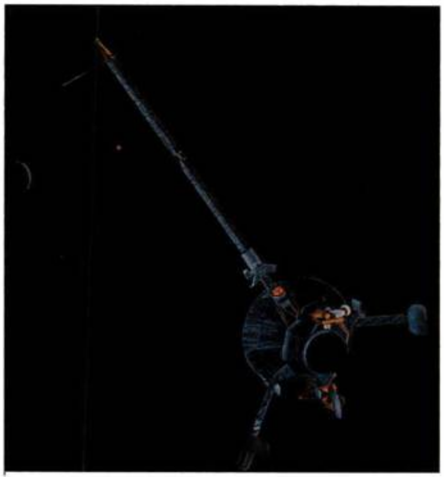
BY DAVID J. EICHER

# Galileo's end of the road

Fourteen years ago, the ground shook at Florida's Cape Canaveral and a tower of steam and smoke shot upward. It marked another launch of the space shuttle Atlantis, this time carrying a special payload — the Galileo spacecraft. Six years later, Galileo arrived at Jupiter and began the first intense investigation of the planet and its system of moons. The Voyagers had whizzed past Jupiter in 1979, providing the first close look at the solar system's giant planet. Galileo's mission, however, would be a journey circumnavigating the jovian globe.

Since 1995, Galileo has systematically rewritten our knowledge of Jupiter and its moons. It has studied the jovian atmosphere and magnetic field, and it carefully imaged the volcanoes of Io and the cracked, icy surface of Europa. It has discovered many satellites orbiting the jovian system, some 21 in 2003 alone, bringing the current total to 61. And now, after eight years of hungrily taking data, Galileo will plunge into Jupiter's atmosphere on September 21 and vaporize in the heat of Jupiter's core.



**THE GALILEO SPACECRAFT** explored Jupiter and its moons, including Io, shown in this artist's image with a distant, tiny Sun. NASA/JPL

This issue contains a special report on Galileo's findings, concentrating on the recent inspection of the inner moon Amalthea, written by journalist and astronomical artist Michael Carroll. "The long goodbye" (page 36) will surprise you with the many discoveries planetary scientists made during this mission, as well as the unexpected hurdles they had to overcome.

Although it is king of the planets, Jupiter is not the most studied object in the galaxy. The Orion Nebula, familiar as that misty spot below the Hunter's belt, deserves that title. University of Michigan astronomer Ray Jayawardhana's intimate portrait of the nebula known as M42, "Style & substance," begins on page 42. Taking a jump farther out into the cosmos, read "The outsider" by contributing editor Bob Berman (page 48). This profile of Columbia University's eccentric genius astronomer David Helfand will no doubt entertain and amaze you. Helfand's research interests include large-scale structure of the cosmos, neutron stars, supernova remnants, and active galaxies. Professor Helfand exudes a captivating personality.

As always, feel free to contact me to let me know your reaction to the magazine. E-mail me at editor@astronomy.com. I will always be listening.

Yours truly,

Dave Eicher
Editor

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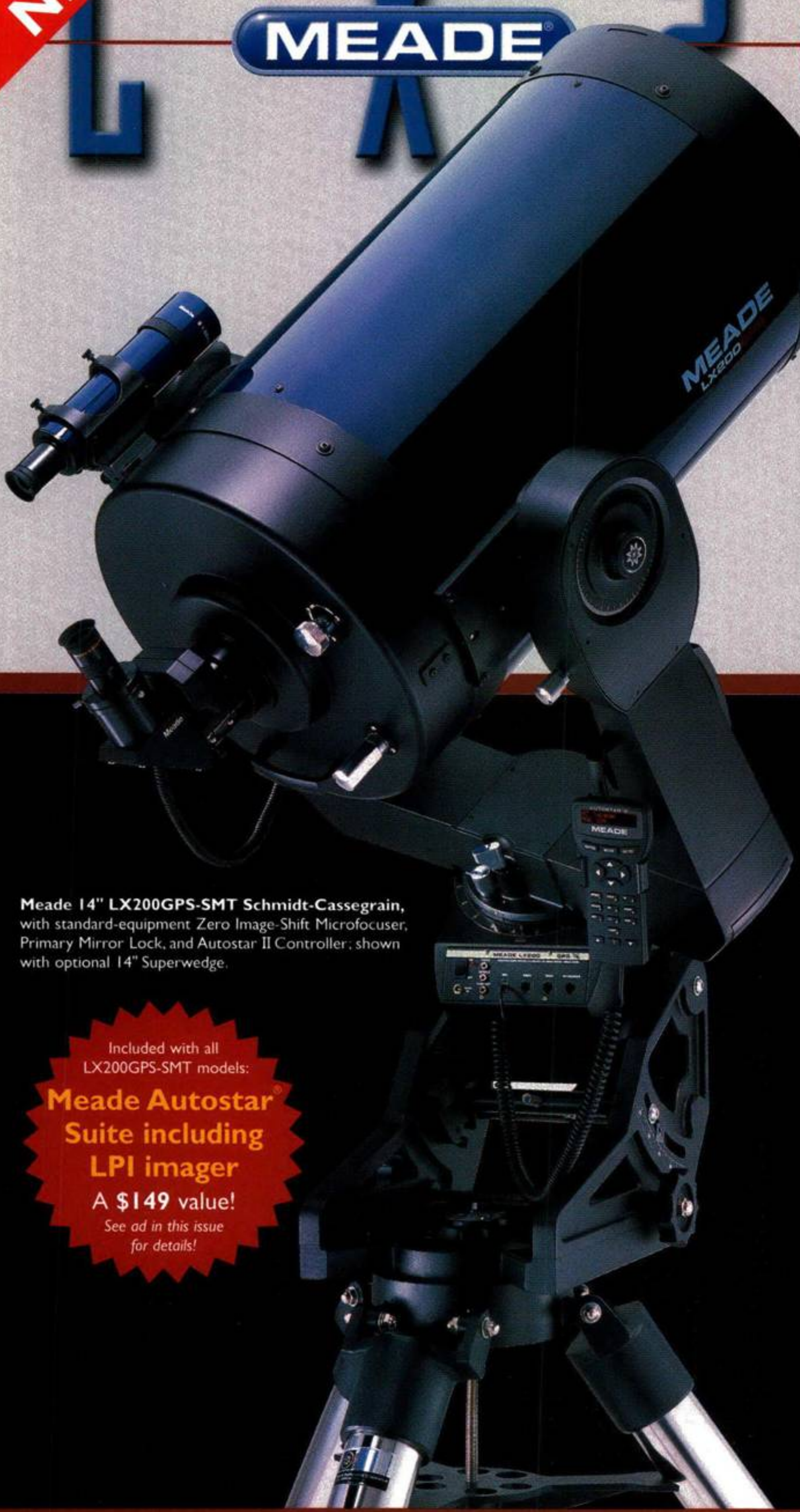

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Facing page *(right to left)*: Meade 7" LX200GPS-SMT Maksutov-Cassegrain; 8", 10", and 12" LX200GPS-SMT Schmidt-Cassegrains.

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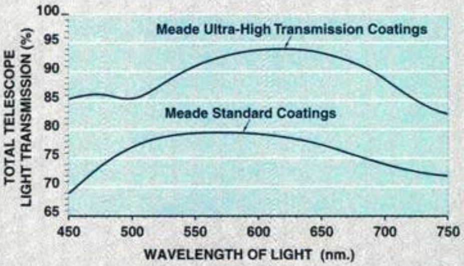

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| Morphological Catalog of Galaxies | 12,939 |
| General Catalog of Variable Stars | 28,484 |
| SAO, Hipparcos, and Draper Star Catalogs | 63,404 |
| Yale Bright Star Catalog (BSC5) | 6,150 |
| Large Bright Quasars Survey (LBQS) | 1055 |
| Messier (M) and Caldwell Catalogs | 219 |
| Named Objects | 227 |
| Herschel Catalog | 400 |
| Abell Catalog of Galaxy Clusters | 2712 |
| Arp Catalog of Irregular Galaxies | 645 |
| Major planets from Mercury to Pluto | 8 |

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## #1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate handbox for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries. **$249.95** (9.85)

## Series 4000™ Super Wide Angle
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For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above. **Super Wide Angle** (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

## Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

## CCD-Photo-Visual Flip-Mirror Systems

Use with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

**#644 Flip-Mirror System:** Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

**#647 Flip-Mirror System:** Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

**#157 1.25" Adapter:** Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

## Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

## Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

**Series 4000 Photo-Visual Color Filters** (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

**#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue** — each **$14.95** (2.73)

| | |
|---|---|
| **Set #1**–4 filters: #12, #23A, #58, #80A | **49.95** (4.54) |
| **Set #2**–4 filters: #11, #25A, #47, #82A | **49.95** (4.54) |
| **Set #3**–4 filters: #8, #21, #38A, #56 | **49.95** (4.54) |

**Series 4000 Moon Filter (#ND96):** Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

## #905 Variable Polarizer (1.25")

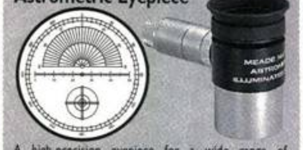
For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

## World's Most Advanced Illuminated Reticle Eyepiece

**Series 4000 Plössl 9mm,** with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

**Series 4000 Plössl 9mm**—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

## MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photoguiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

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## Series 4000™ 2x Apochromatic Barlow Lens

**#140:** The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

## 2x Short-Focus Barlow (1.25")

**#126:** Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

## New! 2" Diagonal Mirrors with UHTC

**#929:** Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders. **#929** or **#930,** each: **$119.95** (6.85)

## 45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces). **$42.95** (3.86)

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**#776** Case for ETX-105 models: **99.95** (8.58)
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## Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

**#1244 Electric Focuser** for all ETX-90 and ETX-105 models: **$119.95** (6.85)

**#1247 Electric Focuser** for ETX-125 models: **$119.95** (6.85)

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Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

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Threads into the front lens-cell and effectively inhibits the formation of dew on the lens surface.

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| **#678** for ETX-125 | **29.95** |

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Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry Meade accessories in-stock for immediate shipment:**

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**A long listing of standard-equipment features** including rigid fork mounts; dual-axis drive systems with high-torque DC motors on both telescope axes; cordless field operation from eight (user-supplied) AA-batteries that power the telescope for more than 20 hours of normal usage; and internal flip-mirror system for observing or imaging from either the 90° or straight-through positions.

**#497 Autostar Controller:** The patented Meade Autostar controller brings automatic GO TO operation, plus dozens of additional menu options, to your fingertips, with a database of more than 30,000 celestial objects, including 5,386 galaxies, nebulae and star clusters from the Index Catalog (IC); 7,840 objects from the New General Catalog (NGC); 110 Messier objects; the major planets from Mercury to Pluto; and more.

**#884 Deluxe Field Tripod:** Constructed of strong, lightweight steel, the full-length Meade #884 Deluxe Field Tripod provides a rigid mounting platform for virtually any ETX observing application. Tripod height is adjustable for seated or standing observing. Use in either equatorial or altazimuth orientations; a graduated scale permits precise polar alignment. For Autostar applications, or for terrestrial observing, the tripod locks to 90°.

Each supplied with #497 Autostar Controller and #884 Deluxe Field Tripod:

| | |
|---|---|
| **ETX-90AT Astro Telescope** | **$595** |
| **ETX-105AT Astro Telescope** | **795** |
| **ETX-125AT Astro Telescope** | **995** |

**Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: ETX-90AT– $50; ETX-105AT– $75; ETX-125AT– $95

Alternately, for the beginning-to-intermediate observer, the ETX-70AT is supplied with #494 Autostar Controller and #882 Field Tripod:

| | |
|---|---|
| **ETX-70AT Astro Telescope** | **299** |

Packing & shipping (ETX, Autostar, & Tripod): ETX-90AT — $30; ETX-105AT — $35; ETX-125AT — $40; ETX-70AT — $20.

**Meade ETX-125AT**
Shown with standard-equipment #497 Autostar Controller and #884 Deluxe Field Tripod.

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# A peculiar galaxy

The giant elliptical galaxy Centaurus A (NGC 5128) stands as one of the more unusual galaxies in the sky. Although most ellipticals have little gas or dust, Centaurus A features a broad dust lane. Astronomers think the dust represents the remains of a companion galaxy merging with Centaurus A. Some of the incoming material feeds a supermassive black hole in the galaxy's heart, powering prodigious radio and x-ray emission. Centaurus A lies about 13 million light-years from Earth. This image was taken with the Wide-Field Imager on the European Southern Observatory's 2.2-meter telescope in Chile.

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A3AA

# Earth's atmosphere "just right"

"Goldilocks & the three planets" (July 2003), like many articles I have read about the development of the atmosphere and life on Earth, ignored the possible influence of the Moon on these processes. ☾ It appears that land animals arose after an amphibious phase in the inter-tidal period of life development, so could it be argued that without such a period, land animals might have had some difficulty evolving? Because the Moon creates tidal effects in the oceans, could it also be inferred that such effects extend to the molten parts of Earth's core?

Three planets exhibit past effects of tectonic plate movement, yet only one exhibits present-day tectonic movement. Uniquely among the three, this planet has a giant moon. Perhaps I am being overly simplistic, but surely there must have been some effect. — **KENNETH J. R. SMITH,** DUBAI, UNITED ARAB EMIRATES

It seems to me including the giant impact that created the Moon in the model would be critical in explaining how our present life-supporting atmosphere developed.

Is it not true that the impact of a Mars-sized body thought to have created the Moon also would have blasted away most of the presumably thick primordial atmosphere? All else being equal, Earth should have a thicker atmosphere than Venus because Earth is farther from the Sun and slightly bigger than Venus.
— **TIM BOYLE,** TSUKUBA, JAPAN

Naomi Lubick refers to methane as "smelly" and "noxious." In fact, it is both colorless and odorless. Methane's undeserved reputation stems from its association with other gases, notably hydrogen sulfide and sulfur dioxide. Methane itself, however, is blameless.
— **CHARLES H. DAVIS, PH.D.,**
INDIANA UNIVERSITY AT BLOOMINGTON

**VOLCANIC ERUPTIONS** and plate tectonics eject trapped greenhouse gases that keep our planet warm — and habitable. NASA

### Star Hill Inn

As cofounder of Star Hill Inn, I read with great interest your article in the July issue ("A visit to Star Hill Inn," 2003). As the article states, Mr. Mahon had the idea for Star Hill after reflecting on his T-shirt and the amateur astronomy market, but a partnership brought the project to fruition.

During Star Hill's first years, Mahon was employed full-time at a title company. For the first twelve years, in addition to other responsibilities, I designed residential improvements (with the exception of Sunrise House) and landscaping, developed both marketing plans and annual educational workshops, and provided other administrative support.

Currently, I am executive director of RavenStar, a nonprofit organization that provides hands-on astronomy education for thousands of students yearly. My family and I take pride in Star Hill's success; we would appreciate acknowledgement of our contributions. — **BLAIR BROWN MOORE,** NEW BRAUNFELS, TEXAS

### Safety first

The tragic loss of the space shuttle Columbia and its crew cast a dark cloud over the future and safety of our manned space program (see "Trial by Fire," July 2003). What happened to NASA's technological mastery of human space flight? The space shuttle has claimed the lives of 14 astronauts and is not safe enough to keep flying without any means for our astronauts to escape deadly accidents.

NASA announced last December that, after 17 years, a teacher would fly in space. Barbara Morgan, a science teacher from McCall, Idaho, who was Christa McAuliffe's backup in 1986, will be on her way to the International Space Station this coming November.

I have been a strong advocate for the reinstatement of the Teacher in Space Program, but now I have grave second thoughts. I wonder whether the risk is worth the price. An escape pod system could have saved lives in both the Challenger and Columbia catastrophes. If manned space flight is put on hold for five or ten years, so be it! Astronaut safety must be NASA's primary mission.
— **RICK SCHREINER,** PASADENA, CALIFORNIA

### Correction

On page 40 of the July issue, images of Mars and Venus are reversed; contrary to the caption, Venus actually appears on the left, and Mars is on the right.
— ***ASTRONOMY* EDITORS**

*We welcome your comments. Send letters to Astronomy Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

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- **Auto North and Level Compatible (with optional CN16 GPS Accessory)** — Automatically finds north and level with more precision than can be done by hand, getting you closer to your alignment stars.
- **Hibernate** — This power saving feature lets you power down the telescope without losing your alignment (input time if CN16 GPS accessory is not attached). Great for finding planets in the daytime after aligning at night or observing day after day without having to re-align.
- **Database Filter Limits** — User-defined so that only objects visible above the horizon are displayed on the hand control.
- **Wedge Align Algorithm** — Automatically aligns the telescope to the celestial pole. Essential when you are performing polar alignment on an Equatorial wedge.
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The beauty of Celestron's NexStar GPS telescopes has always been their unique appearance characterized by their **patented** design, engineering innovations like **patented** AutoAlign, user-friendly intuitive software, and solid aluminum construction. We've made them even more attractive by upgrading the software with additional new features that are ***included with all Celestron NexStar GPS telescopes including our 5i and 8i.***

### Software Features:

- **Compass Calibration** — Allows you to point to true north more accurately, by compensating for magnetic north offset and local anomalies.
- **Polar Alignment Routine** — Facilitates polar alignment for CCD imaging or conventional 35mm astrophotography.
- **EQ AutoAlign** — Now the patented AutoAlign is available even when the telescope is mounted on a wedge.
- **Database Filter Limits** — Now available in Equatorial mode as well as Alt/Az.

**NexStar 8i NOW AVAILABLE WITH OPTIONAL**
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**HIGH PERFORMANCE OPTICAL SYSTEM**

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NexStar 5i shown with included Computerized Hand Control and Tripod. Cameras and accessories for astrophotography are optional.

NexStar® 5i
**$999***
+ $50 Shipping & Handling

NexStar 8i shown with included Computerized Hand Control and Tripod. 1.25" Ultima Ocular, and CN16 GPS Accessory are optional.

NexStar® 8i
**$1299***
+ $75 Shipping & Handling

*Suggested Mail Order Retail Price

### Optional CN16 GPS Accessory

**CN16GPS Accessory** — #93963 Mounts to both the NexStar 5i and 8i. Converts the telescope to GPS align for automatic alignment without manually entering any data. — **$199**

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# The antisolar point

Open any astronomy text and check the index for "antisolar point." Result: nothing. It's ignored as thoroughly as a teenager's curfew. Yet that strange place hosts an exciting mixture of phenomena — including this season's main event. ☾ The antisolar point is the spot opposite the Sun, duh. By day, it's marked by the shadow of your head. At night, it's the most happening place in the heavens.

Even ancient cultures picked up on the uniqueness of the antisolar point and kept track of where it lurked in the starry sky. Whenever the Moon wandered into that spot, it went into eclipse without fail, just as it will on November 8. Because that spot marked the location of Earth's shadow, people of ancient cultures knew that a 2-D image of our world must then be cast upon the Moon. This was the reasoning that convinced Aristotle that Earth could be nothing but a sphere. (Some of his C-student friends must have argued that a flat disk can also cast a round shadow, but he surely had the rebuttal handy: A flat disk would sometimes be oriented sideways to the Sun or nearly so, and the shadow then would be a weird straight line, something never seen on the Moon.) Later, Aristarchus calculated the distance to the Moon using the dimensions of Earth's shadow.

After our planet's shadow finishes tapering to nothingness approximately 864,000 miles anti-sunward of us, what else might be interesting in that exact direction? Answer: a lot.

Planets farther from the Sun than Earth are closest to us on the night they venture nearest to or reach the antisolar point. They are also brightest, biggest, and at the exact middle of their strange retrograde motions then, having attained the straight-line geometry known as opposition. Opposition, which of course means floating opposite the Sun in our sky, is where Saturn will lurk on the final day of this year, just a few months from now.

People living far from city lights can sometimes see a faint oval glow marking the antisolar point. This is the Gegenschein, which means counterglow. It's the reflection of sunlight from countless dust grains floating between the planets. Like a beaded movie screen or highway sign that reflects light directionally, only dust precisely opposite the Sun bounces light back to us.

Anyway, that's what they say. I live in an inky dark area where the zodiacal light, aurorae, and other faint phenomena show up routinely, but I've never personally seen the Gegenschein. I trust it's there. Why would anyone make it up?

By day, the antisolar point occupies the exact center of every rainbow. In a normal rainbow caused by sunlight on raindrops, the rainbow is less than a full semicircle and its center lies below the horizon, somewhere on the ground. But when you look *down* upon sunlit water droplets, like the spray of a waterfall when you're perched on a ledge above it, you can see more than half a rainbow, and the antisolar point at its center shows up nicely as the shadow of your head.

When walking near a dewy lawn or looking out an airplane window toward the ground, the antisolar point is marked by a bright glow called the Heligenschein. (Somehow these German terms always sound like a prestigious government medal. Stand at attention, today we honor you with the Heligenschein!)

When your jetliner flies just above a cloud layer, the antisolar point (its position is marked by the plane's shadow) will always be surrounded by a vivid series of colorful rings. This is called the glory. It's quite exciting to see glories, even though they're totally predictable. In the current climate of air travel, it's important to suppress the temptation to jump up and shout to the strangers seated all around you, "I see the glory!"

Unlike rainbows, glories come in a variety of sizes depending on the size of the water droplets. They're one more reason to choose an airplane seat with care, so be sure you get a window seat on the side opposite the Sun. Meaning, choose the left side when flying west-to-east and the right side when going east-to-west.

Even twilight offers wonderful antisolar phenomena. The twilight wedge is that dark blue-gray band that hugs the eastern horizon every day at sunset. This is nothing less than Earth's shadow. It's as reliable as dusk: On a clear day, you simply cannot have a sunset without the twilight wedge vividly materializing.

Less common — maybe five percent of the time — enormous converging rays radiate from the twilight wedge. These dark, angled streaks or alternating blue and pink fans meet and terminate like the point of a V at the antisolar point. Not surprisingly, they're called antisolar rays.

Fifteen minutes after any October sunset, when the Sun is some three degrees below the southwestern horizon, antisolar rays will converge at a point high *above* the northeastern horizon. Yes, *precisely* opposite the Sun. Give that man another Heligenschein!

The Gegenschein. Twilight wedge. Antisolar rays. Heligenschein. Lunar eclipse. The glory. Planetary oppositions. Rainbow centers. What part of the sky offers a greater variety of phenomena?

Or is more neglected? ■

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C6-RGT
[#11046]

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**For more information, visit: www.celestron.com/starbrightxlt**

The new Advanced Series and Advanced Series **Computerized GoTo** telescopes have been designed to offer the novice or more advanced user a selection of models with the **features, quality** and **value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace and accessory tray for superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt- Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector**.** There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's precision **matched** and **hand-figured** optical systems.

***Auxiliary ports for Hand Control, Dec Motor and AutoGuider.***

## CG-5 Mount — Precision engineered for stability.

Our new German Equatorial mount has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger** and **more substantial** legs that offer excellent damping characteristics for more stable views. The CG-5 also has a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments.

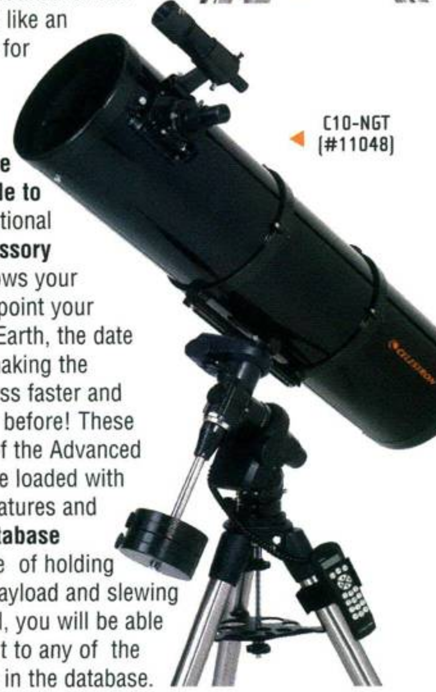
### Additional Specifications — Computerized Models

| | |
|---|---|
| **Hand Control** | Double line, 16 character Crystal Display; 19 fiber optic backlit LED buttons |
| **Motor: Type** | DC Servo motors with encoders, both axes |
| **Max Slew Speed** | 4°/second |
| **Software Precision** | 24bit, 0.08 arcsec calculation |
| **Hand Control Ports** | RS-232 communication port on hand control |
| **Motor Ports** | Aux Port, Autoguide Ports |
| **Tracking Rates** | Sidereal, Solar and Lunar |
| **Tracking Modes** | EQ North & EQ South |
| **Alignment Procedures** | AutoAlign, 2-Star Alignment, Quick Align |
| **Database** | 40,000+ objects, 400 user defined programmable objects |

## GoTo convenience and GPS compatibility for precision accuracy.

C9¼-SGT
[#11046]

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included **NexStar computer control system** and utilize many of the same features as Celestron's most advanced GoTo telescopes like an **Autoguider port** for long exposure deep sky astro-photography. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963).** It allows your telescope to pinpoint your position on the Earth, the date and time, and making the alignment process faster and easier than ever before! These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4º per second, you will be able to instantly point to any of the celestial objects in the database.



**NEW 2003 PRODUCT GUIDE**

**To request a copy of our new 2003 Product Guide, contact us at (310) 328-9560.**

### Specifications — All Advanced Series Telescopes

| | 21016<br>C4-R | 11071/11072<br>C5-S | 31056<br>C6-N | 21019/21020<br>C6-R | 11025/11024<br>C8-S | 31061/31062<br>C8-N | 11045/11046<br>C9 1/4-S | 11047/11048<br>C10-N |
|---|---|---|---|---|---|---|---|---|
| **Optical Design** | 102mm (4.0") refractor | 127mm(5") Schmidt-Cassegrain | 150mm (6.0") reflector | 150mm (6.0") refractor | 203mm (8") Schmidt-Cassegrain | 200mm (8.0") reflector | 235mm (9.25") Schmidt-Cassegrain | 254mm (10") reflector |
| **Focal Length** | 1000mm f/10 | 1250mm f/10 | 750mm f/5 | 1200mm f/8 | 2032mm f/10 | 1000mm f/5 | 2350mm f/10 | 1200mm f/4.7 |
| **Finderscope** | 6x30 | 6x30 | 6x30 | 9x50 | 6x30 | 9x50 | 6x30 | 9x50 |
| **Mount** | CG-4 Equatorial | CG-5 Equatorial | CG-4 Equatorial | CG-5 Equatorial | CG-5 Equatorial | CG-5 Equatorial | CG-5 Equatorial | CG-5 Equatorial |
| **Eyepiece** | 1-1/4" – 20mm (50x) | 1-1/4" – 25mm (50x) | 1-1/4" – 20mm (38x) | 1-1/4" – 20mm (60x) | 1-1/4" – 25mm (81x) | 1-1/4" – 20mm (50x) | 1-1/4" – 25mm (94x) | 1-1/4" – 20mm (60x) |
| **Star Diagonal** | 1-1/4" | 1-1/4" | n/a | 1-1/4" | 1-1/4" | n/a | 1-1/4" | n/a |
| **Accessory tray** | yes | yes | yes | yes | yes | yes | yes | yes |
| **Tripod** | Aluminum | 2" Stainless Steel | Aluminum | 2" Stainless Steel | 2" Stainless Steel | 2" Stainless Steel | 2" Stainless Steel | 2" Stainless Steel |
| **CD ROM** | The Sky Level 1 | The Sky Level 1 | The Sky Level 1 | The Sky Level 1 | The Sky Level 1 | The Sky Level 1 | The Sky Level 1 | The Sky L1 |

**PRICING*:** C10-NGT (#11048): $1,149 + $95 S&H; C10-N (#11047):$849 + $75 S&H; C9¼-SGT (#11046): $1,699 + $105 S&H; C9¼-S (#11045): $1,399 + $85 S&H; C8-SGT (#11026): $1,299 + $75 S&H; C8-S (#11025): $999 + $85 S&H; C8-NGT (#31062): $949 + $85 S&H; C8-N (#31061): $649 + $65 S&H; C6-RGT (#21020): $999 + $95 S&H; C6-R (#21020): $799 + $75 S&H; C6-N (#31056) $399 +$50 S&H; C5-SGT (#11072): $1,099 + $75 S&H; C5-S (#11071): $849 + $65 S&H; C4-R (#21016): $399 + $40 S&H

*Prices shown are U.S. mail order.

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{ GLENN CHAPLE'S OBSERVING BASICS }

BY GLENN CHAPLE

# Beyond the Milky Way

In the spirit of the gridiron season, we're going to "go deep" this month — in an astronomical sense. "Going deep" doesn't mean a visit to the Moon, an excursion that will barely get us across the cosmic line of scrimmage. Ditto for the planets or anything else located within our solar system. The stars might get us an interstellar first down. But if we want to ramble into the end zone of deep space, we need to leave the Milky Way and set our sights on another galaxy.

If you're an astronomical newcomer, you may feel a bit overwhelmed at the prospect of seeing so far into outer space. "A galaxy," you gasp. "But I don't own a gazillion-power telescope. How can I expect to see something that far away?" Believe it or not, a galaxy other than the Milky Way can be seen with the naked eye.

The all-sky map in the pull-out at the center of this magazine shows the location of the Andromeda Galaxy, identified as M31. "M31" means the Andromeda Galaxy is the 31st entry in the historic catalog prepared by French astronomer Charles Messier (M) in the late 18th century. A trip to the Andromeda Galaxy begins at the "Great Square" of Pegasus. The star, called Alpha (α) Andromedae, or Alpheratz, in the upper left of the Square is part of the constellation Andromeda. Notice two rows of stars branch out from Alpheratz. To locate the Andromeda Galaxy, start at Alpheratz and move two stars over on the lower row (you'll arrive at Beta (β) Andromedae), then move up two stars. Right next to the final star is a smudge of light about equal in brightness to a 4th magnitude star.

Astronomy books printed before the 1920s called M31 the Andromeda Nebula. Telescopes in those days couldn't resolve the stars in that island universe. What was seen as a glowing whirlpool was assumed to be a swirling gaseous cloud located within our galaxy — a nebula similar to, if not vastly larger than, the one that spawned our solar system. Only after the 100-inch telescope at Mount Wilson, California, revealed the stellar masses that make up M31 — and the fact that one was a particular kind of variable star — was its extragalactic nature revealed.

**THE ANDROMEDA GALAXY,** (M31), is just one of many deep-sky objects you can enjoy with the naked eye or binoculars. JASON WARE

The Andromeda Galaxy is a textbook example of a deep-space object that doesn't have to be viewed with high magnification. Binoculars transform that indistinct, naked-eye smudge into a small, oval-shaped, misty patch — the nucleus of the Andromeda Galaxy. The spiral arms are too faint to see with standard binoculars, so we need the light-gathering boost of a telescope. M31 spans almost ten Full Moon diameters at its greatest dimension. My best view of the Andromeda Galaxy came from a low-power, rich-field telescope that magnified just 16x.

If you look carefully, you'll see M31 isn't the only galaxy in town. To either side of the great ellipse is a small companion galaxy. M32 appears condensed and star-like; M110 is larger and more diffuse. Because of their relatively small size, each is best viewed with telescopic magnifications between 30x and 100x. M31 and M110 are gravitationally bound to the Andromeda Galaxy the way the Magellanic Clouds cling to our Milky Way.

Appearing as rather unspectacular blobs of light, galaxies don't have the in-your-face visual impact of Saturn or the Moon. To be awed by the sight of the Andromeda Galaxy (or any galaxy, for that matter) you have to know the true nature of what you're looking at. That smudge of light comes from more than two hundred billion stars. If it's true that a bucket can hold one million grains of sand, we'd need more than two hundred thousand buckets to hold enough sand grains to equal the number of stars in the Andromeda Galaxy.

The Andromeda Galaxy is thousands of times more remote than the stars in the Milky Way. Studies of Cepheid variable stars (a prime indicator of distances in space) in the Andromeda Galaxy place it at 2.6 million light-years away. When you gaze at M31, the light photons striking your retina left at a time when elephants roamed pre-Ice Age North America.

Here's another mind-boggling thought. You've probably read about the possibility of intelligent life in the universe based on mathematical probabilities. Someone may estimate one in a billion stars possesses a planet with conditions amenable to intelligent life. With those odds, there is still room for several hundred sentient civilizations in the Andromeda Galaxy.

While the Moon or Saturn may jump at my eyes, the Andromeda Galaxy leaps at my mind. Let it do the same for you.

NEXT MONTH: Another chance in 2003 to see a lunar eclipse and a holiday preview of beginner-oriented binoculars and telescopes. Clear skies.

# NEW Celestron StarBright XLT High Performance Optical Coatings Outperform The Competitor's UHTC.

**StarBright XLT — An Optical System Breakthrough!** Celestron has taken its renowned StarBright technology to *an even higher level of light transmission* with the introduction of our new **optional** StarBright XLT High Performance Optical Coating System.

### StarBright XLT Optical System Design — You'll See The Light.

One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use *and* for CCD/Photographic imaging.

### Celestron StarBright XLT: The Bottom Line.

- **11% brighter than UHTC across the spectrum from 400nm to 750nm.** (See Fig.#1)
- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

### Coming Out of the Dark — StarBright XLT Performance Where It Counts

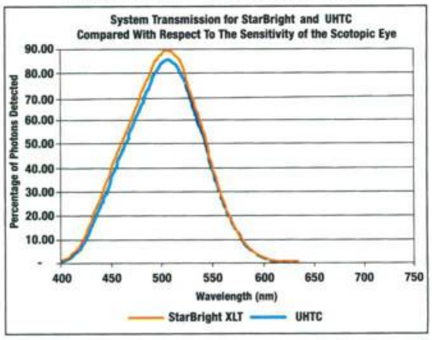

***Fig #3:** The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a **6% improvement over UHTC** for visual observing .**

### System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

| | Wavelength (nm) | StarBright XLT | UHTC Measured | Percent Improvement |
|---|---|---|---|---|
| H-beta | 486 | 87.5 | 83.0 | **5%** |
| Helium II and $O_3$ | 496 | 88.0 | 84.0 | **5%** |
| $O_3$ | 501 | 88.0 | 84.3 | **5%** |
| Center of dark adapted vision | 510 | 88.7 | 84.8 | **5%** |
| Helium I | 588 | 88.0 | 81.6 | **8%** |
| $N_2$ | 655 | 84.0 | 73.8 | **14%** |
| $N_2$ and H-alpha | 658 | 84.0 | 73.0 | **15%** |
| Sulfur II | 673 | 83.0 | 72.0 | **15%** |

### System Transmission for StarBright XLT and UHTC

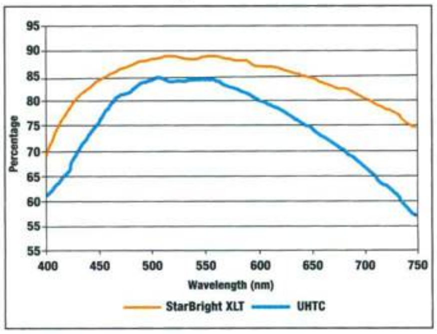

***Fig #1:** This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

### CCD Imaging — It's All In The Photons

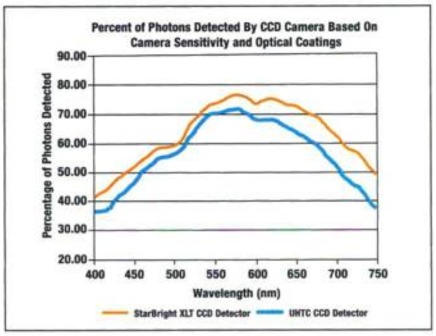

***Fig #2:** StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

### UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: **www.celestron.com/starbrightxlt**.*

****Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.***

**The StarBright XLT System — What makes it different makes it better. —** There are three major components that make up our StarBright XLT high transmission optical system design:

1. **Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), $SiO_2$ (quartz), $TiO_2$ (titanium dioxide), and $SiO_2$. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
2. **Multi-layer anti-reflective coatings** — Made from precise layers of $MgF_2$ (magnesium fluoride), and $HfO_2$ (hafnium dioxide). A rare element costing nearly $2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.
3. **High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with **optional** StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. ***Water white glass transmits about 90.5% without anti-reflective coatings***. That is 3.5% better transmission than uncoated soda lime glass. ***When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!***

**For more information about StarBright XLT visit: www.celestron.com/starbrightxlt**

### StarBright XLT Pricing

| | |
|---|---|
| All 8" Schmidt-Cassegrain Products | $125 |
| All 9.25" Schmidt-Cassegrain Products | $175 |
| All 11" Schmidt-Cassegrain Products | $225 |
| All 14" Schmidt-Cassegrain Products | $275 |

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BY WILLIAM SCHOMAKER

# Phil Plait

## Self-proclaimed "bad astronomer"

Phil Plait wears his disparaging badge of distinction proudly, but don't let the moniker fool you. By day, he's an accomplished astronomer and research manager at Sonoma State University in Northern California. And by night, he sets out, armed with his web site (www.badastronomy.com) and his wit, to right the wrongs of astronomical illiteracy — and have a little fun, too. Catapulted to mainstream success with a scathing evisceration of the infamous FOX television special "Conspiracy Theory: Did We Land on the Moon?," Plait's site sports an active following of star lovers and skeptics alike and was named one of *Popular Science*'s "Top 50 Science Sites on the Web."

**You're dead serious about correcting media misuse and public misunderstanding of astronomy, but you make a point to keep your site light and humorous. Why?**

A lot of skeptics are really earnest, and reading a web page written by someone like that can be deathly dull. Astronomy is many things, but it isn't boring. So, why portray it that way?

I love astronomy, and I have fun with it, so that's the way I write. I could beat people over the head with my point, but it's unlikely they'll walk away either understanding what I'm trying to say or caring about it. Making it humorous is a great way to keep people's attention and help them retain the information, too.

**Did you ever dream your web site would become such a hit?**

**PHIL PLAIT** arouses curiosity in the truth about our universe, as bad astronomy lulls society into an ignorant stupor. PHIL PLAIT

Never. It started in 1993 as a place for me to vent about astronomical misconceptions. But this was back when the Internet was young, and I was happy to get twenty hits a month. Then, in February 2000, FOX aired that execrable show claiming that the Apollo Moon landings were faked. Things have never been the same since. From an advanced copy of the show, I prepared a point-counterpoint rebuttal. After the show aired, my page was quoted by CNN and NASA. I heard 15 million people watched the show when it was aired in the United States. Since then, I've had over a million hits to that web page alone, and it now gets several million hits a year.

**Unrealistic and manipulative scripts are cheaper-by-the-dozen in Hollywood. Isn't a little suspension of disbelief good for us?**

Of course it is. But while it's fun and not too hard for audiences to suspend disbelief that we can make a machine that can burrow to Earth's core, how many people actually bought the explanation in *The Core* about what Earth's magnetic field does? The explanation in the movie was utter nonsense, yet several actors from the film did interviews gushing about how accurate it was. It's stuff like this that I'm trying to fix.

**Where do you draw the line between creative misdirection and irresponsible media behavior?**

The FOX show about the Moon landings crossed that line. The show was presented as a documentary, but in fact, it was grossly uncritical and ridiculously incorrect in almost everything it portrayed. Kids watched that show and began to doubt one of the greatest achievements of the 20th century.

I got an avalanche of e-mails from teachers who said their students came up to them the day after the airing of that "documentary" saying the Apollo missions were faked. Calling FOX irresponsible for airing that piece of garbage is really the *least* you can do.

**What's the worst astronomy misconception currently floating around?**

There are hundreds of examples of bad astronomy, but perhaps the most widespread one isn't a specific one. It's the idea that astronomy is hard to understand, it's boring, and it's too complicated. I hear these all the time. How can you not stop and wonder about a universe that has no center, is expanding at an accelerating rate, and 94 percent of which is made up of substances we can only guess at?

The study of astronomy is the study of who we are and what our place is in the universe. If there's anything less boring than that, I can't imagine what it is. ◼

# SkyMaster™

- Value priced
- Waterproof (80mm and 100mm)
- Multi-coated optics
- High index BAK-4 prisms
- Integrated tripod adapter
- Long eye relief
- Lifetime Warranty

## LARGE APERTURE BINOCULARS

NEW!
SkyMaster

70mm model comes with a tripod adapter.

*Model 71009*
*15x70*
$89

Object: Hale-Bopp Comet
Photographer: Dean Koenig

80mm and 100mm models come with a deluxe padded soft carrying case.

Celestron's new SkyMaster Series of large aperture **porro prism** binoculars offer phenomenal performance for astronomical viewing or low light conditions. They are also a great choice for terrestrial use, especially over long distances. All models feature high quality **BAK-4 prisms** and have **multi-coatings** for enhanced contrast. The 80mm and 100mm models are **waterproof** and feature an integral **super rigid photo tripod adapter for structural reinforcement** of the main body and maximum stability and secure optical alignment. The 15x70 model is **lightweight** and features a **tripod adapter.**

*Model 71017*
*25x100*
$349

*Model 71016*
*20x80*
$299

## SPECIFICATIONS

| MODEL | 71009 | 71016 | 71017 |
|---|---|---|---|
| Size | 15 x 70 | 20 x 80 | 25 x 100 |
| Prisms | BAK-4 | BAK-4 | BAK-4 |
| Focus | Center | Individual | Individual |
| Coating | Multi-Coated | Multi-Coated | Multi-Coated |
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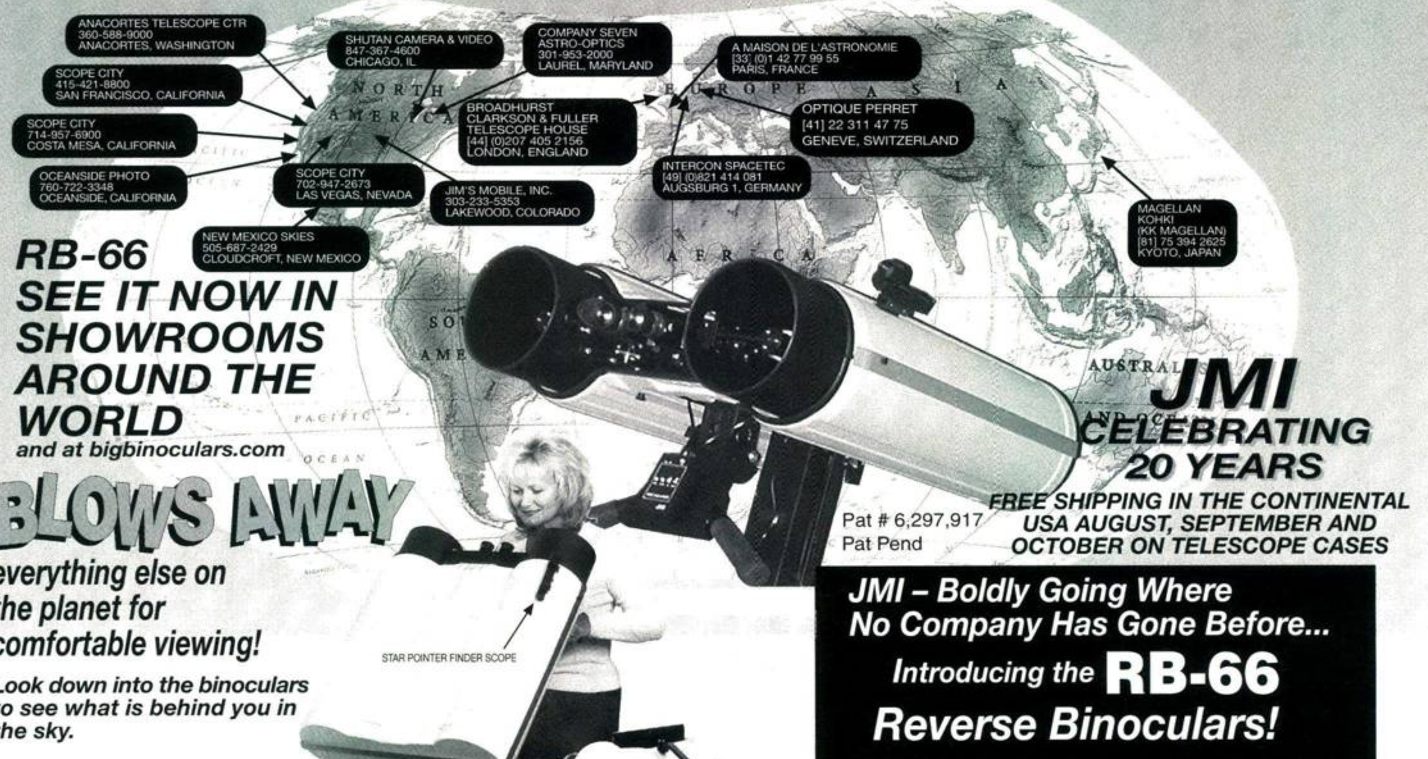
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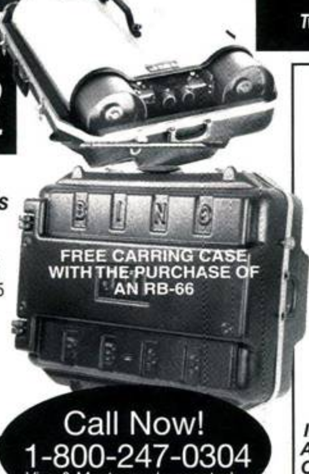
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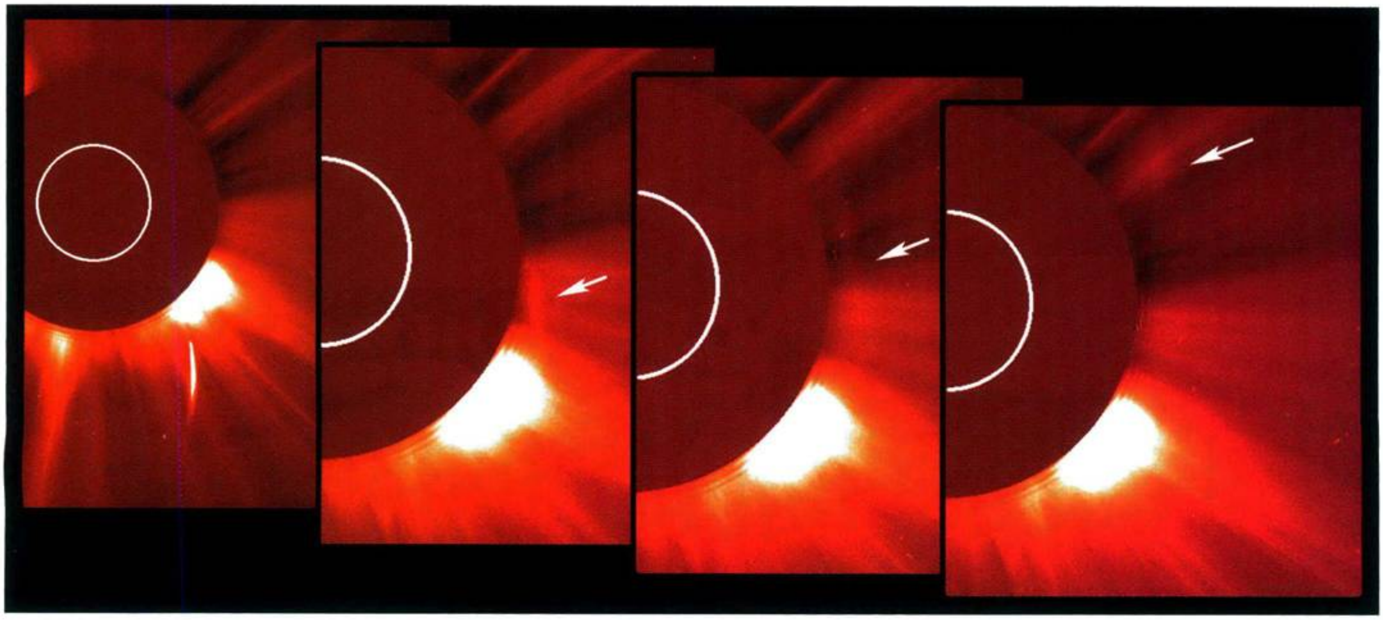
{ 10:03 } TWO BANDS OF DUST IN THE SOLAR SYSTEM, discovered by the InfraRed Astronomy Satellite (IRAS) in 1983, have now been linked to the Veritas and Karin asteroid families, which broke up 8.3 and 5.8 million years ago, respectively.

# news 10

Read all about it: Gamma-ray bursts linked to supernovae, spotted terrain on Mars, the flattest star in the known universe, and variable stars in Centaurus A.



**TWO SUNGRAZING COMETS**, one much brighter than the other, close in on the Sun in a series of images taken by the Solar and Heliospheric Observatory satellite. Most sungrazers are destroyed completely by the Sun's heat. In this unusual case, dust from the larger comet survived. NASA/GODDARD

**COMET SCIENCE**

## Comets take on the Sun

A snowball took on the Sun recently — and won, sort of. On May 24, 2003, two sungrazer comets passed only 0.1 solar radius — 43,000 miles (70,000 kilometers) — from the Sun's surface. Remarkably, dust from one of the comets survived, even as its icy nucleus vaporized.

The comets were imaged by the Solar and Heliospheric Observatory satellite (SOHO), launched to study the Sun's activity. From time to time, SOHO accidently catches sight of comets passing near the Sun. These two belonged to the Kreutz family of sungrazers, which are fragments of a much larger comet that broke apart in several stages over the last 10,000 years. The family is named for Heinrich Kreutz, a 19th-century German astronomer who discovered the first few member comets.

During SOHO's six-plus years of operation, scientists have seen more than 600 sungrazers sweep through the field of view of its cameras. Just three of these comets have survived.

The dust (arrow) is most likely the remains of the bigger comet's nucleus. Radiation pressure from the Sun pushed it away after all the ice in the nucleus evaporated. Scientists hope studies of the dust cloud's behavior will reveal clues about the size distribution and structure of the dust grains. — **ROBERT BURNHAM**

28 **Supernova in M74**

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32 **Gravity waves may limit pulsar rotation speeds**

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A SUN-LIKE STAR 90 LIGHT-YEARS AWAY has a two-Jupiter-mass planet orbiting it; astronomers say it is the extrasolar planetary system that comes closest in type to our own. If the star were the Sun, the planet would lie in the asteroid belt.

GALACTIC ASTRONOMY

# 1,000 Mira stars

**DISCOVERING MORE THAN 1,000 VARIABLE STARS** in the giant elliptical galaxy known as Centaurus A will give astronomers a better look at how these galaxies form and evolve. ISAAC, VLT, ESO

The first detailed study of variable stars in a galaxy outside our Local Group has turned up more than 1,000 luminous red variables in Centaurus A (NGC 5128), a giant elliptical galaxy 13 million light-years away. The variable stars are mostly "Mira type," which means they vary by more than 2.5 magnitudes over periods that range between 100 and 1,000 days.

Mira, or Omicron (o) Ceti, was the first long-period variable discovered and experiences a 1,500-fold change in brightness over a period of 11 months. Mira is a red giant; nearly all red giants are variable stars. The pulsations in a red giant's luminosity are caused by dramatic fluctuations in the star's temperature and size due to its end-of-life phase.

Astronomers using the European Southern Observatory's 8.2-meter Very Large Telescope ANTU in Chile examined two fields in Centaurus A for three years, creating the deepest infrared images made of the halo of a galaxy that far from Earth.

Detecting the variable stars confirms the existence of intermediate-age stars in the halo of Centaurus A. This provides a window on the stellar contents of giant elliptical galaxies and helps scientists understand how these galaxies form. The relationship between the luminosity and the period in the variable stars' fluctuations also confirms previous distance estimates of Centaurus A. — **KELLY KIZER WHITT**

EXTRASOLAR PLANETS

## Pulsar planet pair

**A dozen years of observations from the Arecibo Observatory have yielded precise measurements of two planets around the pulsar PSR B1257+12. This was the first star discovered (in 1992) to harbor exoplanets.**

**Just 4.3 and 3.9 Earth masses each, B and C are the only known terrestrial-mass exoplanets. Orbiting in nearly the same plane, the planets likely formed from a disk of debris surrounding the pulsar, which rotates every 6.2 milliseconds.**

**"Planets around this strange star much more resemble our solar system than planets around [Sun-like] stars," says Caltech researcher Maciej Konacki, who reported the results at a conference in May.**

**The planetary disk may have been ripped from a stellar companion or created during the merger of two white dwarfs.**

**— MAGGIE McKEE**

BACKYARD ASTRONOMY

## Supernova in M74

On June 12, Robert Evans of Hazelbrook, New South Wales, Australia, was observing the spiral galaxy M74 in Pisces with a 12-inch Newtonian reflector. Evans noticed an unfamiliar star, which turned out to be a bright supernova. Designated SN 2003gd, it shone at magnitude 13.2.

A spectrum of SN 2003gd indicates that it is type II and that it exploded about two months earlier, when M74 was behind the Sun. A type II supernova occurs when a supergiant star's core collapses.

Recently, M74 saw another supernova, SN 2002ap, discovered on January 29, 2002.

Amateur astronomer Evans holds the world record with 37 visual supernova discoveries.

— **MICHAEL E. BAKICH**

**SUPERNOVA 2003gd** was M74's second in two years. DAVID HEALY

PROTOPLANETARY DISKS

# Not just in dusty places anymore

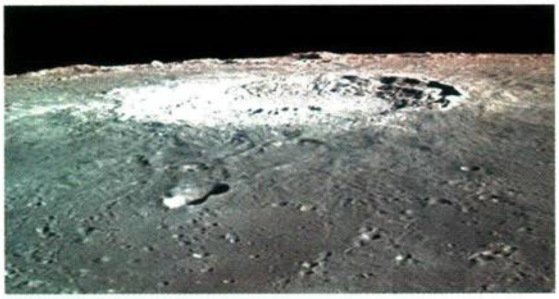
New research suggests that protoplanetary disks around young stars may be more common than astronomers previously thought.

**HUNTING FOR PROTOPLANETARY DISKS** using molecular hydrogen may help scientists find more systems. NASA/STScI

Instead of looking for the dust around planetary disks, which makes them appear larger, Jeff Bary and David Weintraub (Vanderbilt University) searched for hydrogen gas, a disk's main component. Though harder to detect, the gas showed up in the spectrum of an apparently diskless star called DoAr21.

Bary and Weintraub suggest that if dust clumps into planetesimals, which are hard to spot due to their small surface areas, gas could linger in a disk. Thus, some diskless stars may have disks after all. Next step: measuring the gas in such "invisible" disks. — **M. M.**

# Moon Race II: China vs. India



**THE MOON IS THE GOAL** of a new space race between China and India that centers on unmanned probes. Both nations seek to become the dominant space power in Asia. NASA

A replay of the 1960s Moon Race appears imminent — and for space enthusiasts advocating a return to the Moon, it seems like a heaven-sent gift.

Behind the rumors, the Chinese government indeed is developing its Shenzhou human-rated spacecraft for low-Earth orbit, along with a lunar probe. Thus, a real race to the Moon is looming — but China's competitor is not the United States, it's India.

China and India are each preparing for the launch of unmanned lunar orbital and landing vehicles within the next five to ten years. Whoever does it first will gain a significant geopolitical advantage in Asia.

The Chinese project is called Chang Ei, a name from a Chinese myth about a creature that flew to the Moon. Luan Enjie, a space program official, says the project will include lunar satellites to map resources, wheeled rovers with robotic arms, and eventually, a sample-return mission. The latter two missions require the development of an advanced booster called CZ-5, equivalent to a Russian Proton, by 2010. The Moon orbiter mission, however, lies within China's reach; it could be launched by the end of 2005, say knowledgeable space officials.

Sun Jiadong, a senior Beijing-based space expert, told a Chinese newspaper that the "tried and tested" Long March III-A rocket will play a key role in the early phases of the lunar program. The rocket will blast off from the Xichang Satellite Launch Center in southwestern Sichuan province carrying a lunar explorer satellite based on the Dongfanghong III communications satellite.

Meanwhile, Krishnaswamy Kasturirangan, director of the Indian Space Research Organization (ISRO) in Bangalore, declared three years ago that an Indian Moon probe would "electrify the nation." In an interview with the magazine *India Today*, he said, "If we go ahead, it will demonstrate to the world that India is capable of taking up a complex mission that is the cutting edge of space research."

The Indian lunar mission is still in the planning stages, waiting for government approval. It is estimated to cost around 3.5 billion rupees (about $82.5 million US) — far below comparable missions by other space agencies. The 880-pound (400-kilogram) orbiter uses a tested design; it would launch on an Indian-produced PSLV booster and map the Moon from polar orbit.

In using the PSLV to launch a Moon probe, ISRO would further refine its missiles as well as guidance and control systems. The expertise gained in such a project would prove invaluable for building an ICBM that could be targeted accurately.

But the real target for any Moon Race II is the minds of people across Asia. Although a Japanese probe, Hiten, has already become the first Asian Moon probe, China and India are betting that prestige and cash will flow to the launching nation's aerospace business.

— **JAMES OBERG**

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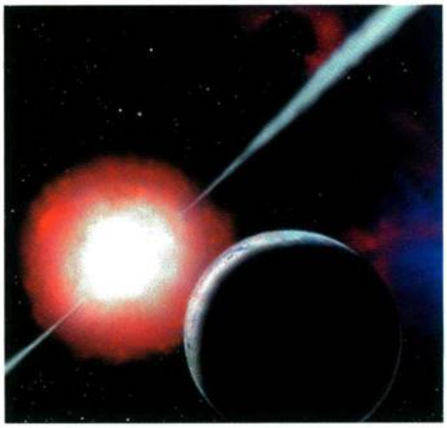
GAMMA-RAY BURSTS

## Supernova-GRB link

Thirty-six years after the discovery of gamma-ray bursts (GRBs), the universe's most powerful explosions, observations are cementing a long-suspected link to supernovae.

A bright GRB raged for about 30 seconds on March 29, 2003 (GRB 030329). It originated in a star-forming dwarf galaxy 2.6 billion light-years away in Leo.



**A SUPERNOVA** may have powered the gamma-ray burst of March 29, 2003. The explosion, seen in an artist's conception, lets astronomers link the two phenomena. DAVID A. AGUILAR, CENTER FOR ASTROPHYSICS

In the June 19 issue of *Nature*, a team led by Jens Hjorth (University of Copenhagen) announced evidence of a powerful supernova at the same time and place, implying the GRB formed after a massive star went supernova. Gamma rays may have arisen when supernova debris jetted out at near-light speed.

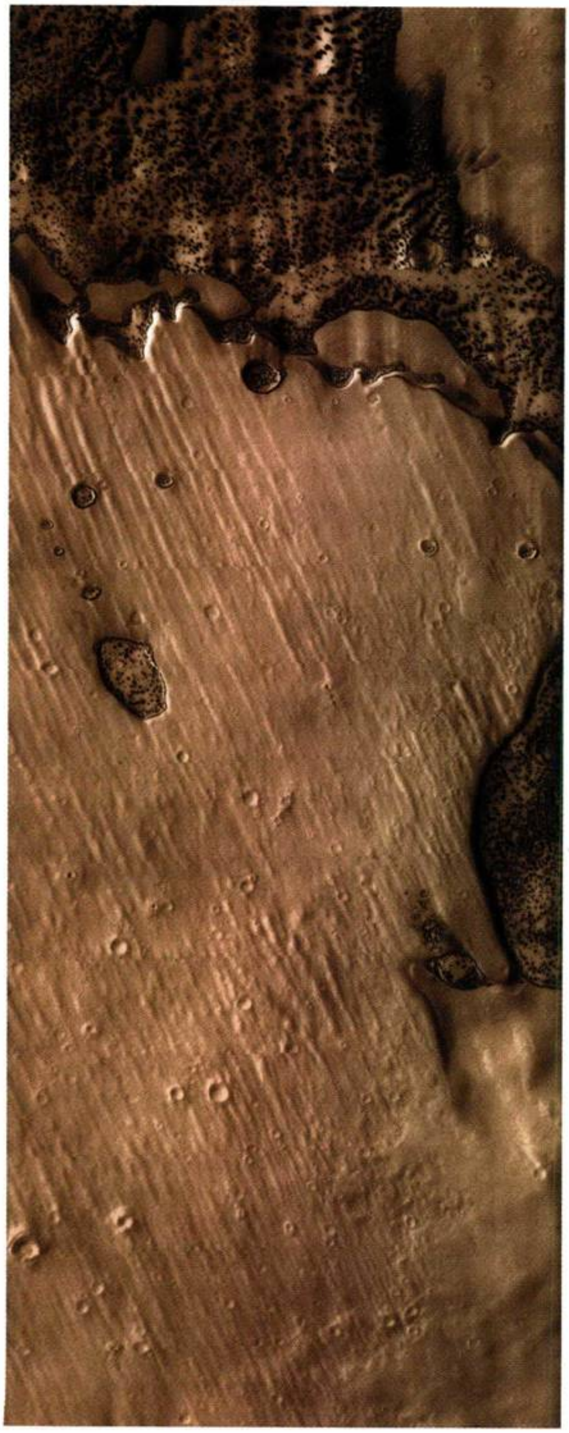
In the May 22 issue of *Nature*, Wayne Coburn and Steven Boggs (University of California, Berkeley) reported polarization in a December 6, 2002, GRB — a first. "It's implying a large-scale magnetic field in the source," says Boggs. Chryssa Kouveliotou (NASA) says, "The next question is, what's the beast in the center?"

Scientists hope NASA's new orbiting observatory, Swift, expected to observe 200 GRBs and their afterglows after its launch this December, may provide the answer. — **M. M.**

GIANT CIRCULATING CURRENTS IN THE SUN drive sunspots toward its equator during the 11-year sunspot cycle, NASA has announced. Currents operate at a depth of 125,000 miles (200,000 km) and flow at about 3 miles (5 km) per hour.

MARTIAN GALLERY

## Dalmatian terrain



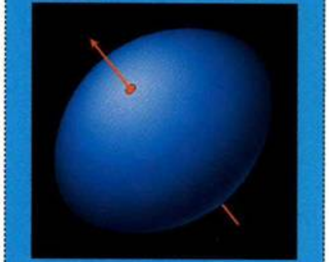
**DARK SPOTS** show where ice has disappeared, revealing bare ground near the martian south pole, as seen by the THEMIS imager on Mars Odyssey. Scientists call the effect "dalmatian terrain." The linear streaks [upper left to lower right] are frost-covered sand dunes. NASA/JPL/ASU/IMAGE 20030701A

STELLAR ASTRONOMY

## Pancake star

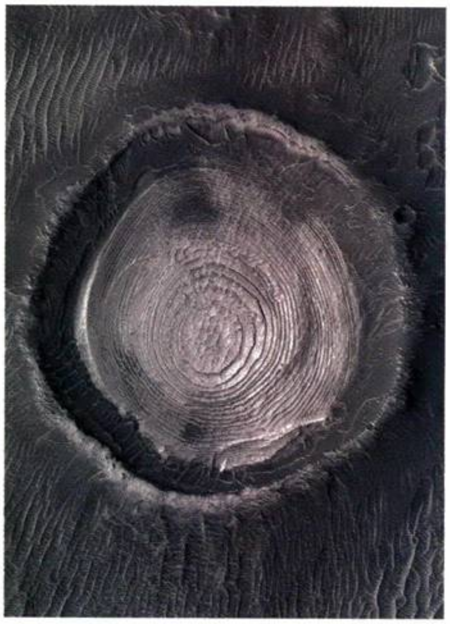
The bright star Achernar in Eridanus is the flattest star known; its radius is 50 percent larger at its equator than at the poles.

Using the European Southern Observatory's Very Large Telescope Interferometer, Armando Domiciano de Souza and colleagues detected the star's bulging figure while studying stellar surface conditions and interiors. — **ANDREW FAZEKAS**



**ACHERNAR** spins so fast it's nearly at the breakup point. Explaining its shape requires new stellar interior models. ESO

## MARS PHOTOJOURNAL



**LAYERS OF SEDIMENT** fill an ancient impact crater in the Schiaparelli basin on Mars. The crater spans 1.4 miles [2.3 kilometers]. Geologists think sediment completely filled the crater before erosion carved its present form. The layers may have been deposited in a lake filling the crater or by debris settling out of the atmosphere. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE R06-00195

SOLAR ASTRONOMY

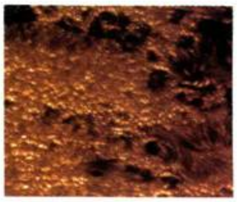
## The Sun's surface is rough

The granulation pattern seen on the Sun's surface is as bumpy as the surface of vigorously boiling water. Newly released images taken near the solar limb in July 2002 with the 1-meter Swedish Solar Telescope have the highest resolution ever taken.

The sideways viewing angle was chosen to bring out the surface structure. The images reveal more three-dimensional detail on the Sun's surface than astronomers have previously seen.

Solar scientists attribute the bumps to convection cells of hot gas in the Sun's upper layer. Bruce Lites (High Altitude Observatory) estimates the light-tinted granules in the image rise about 125 to 280 miles (200 to 450 km) above the dark layer that forms the bottom layer of sunspots.

In addition, many individual granules show bright faces when viewed through a telescope. These are faculae, regions where gas is hotter than its surroundings. — **R. B.**



**SHARP IMAGES** of the Sun's surface show that granules have vertical structure. ROYAL SWEDISH ACADEMY OF SCIENCES/LOCKHEED-MARTIN SOLAR AND ASTROPHYSICS LAB

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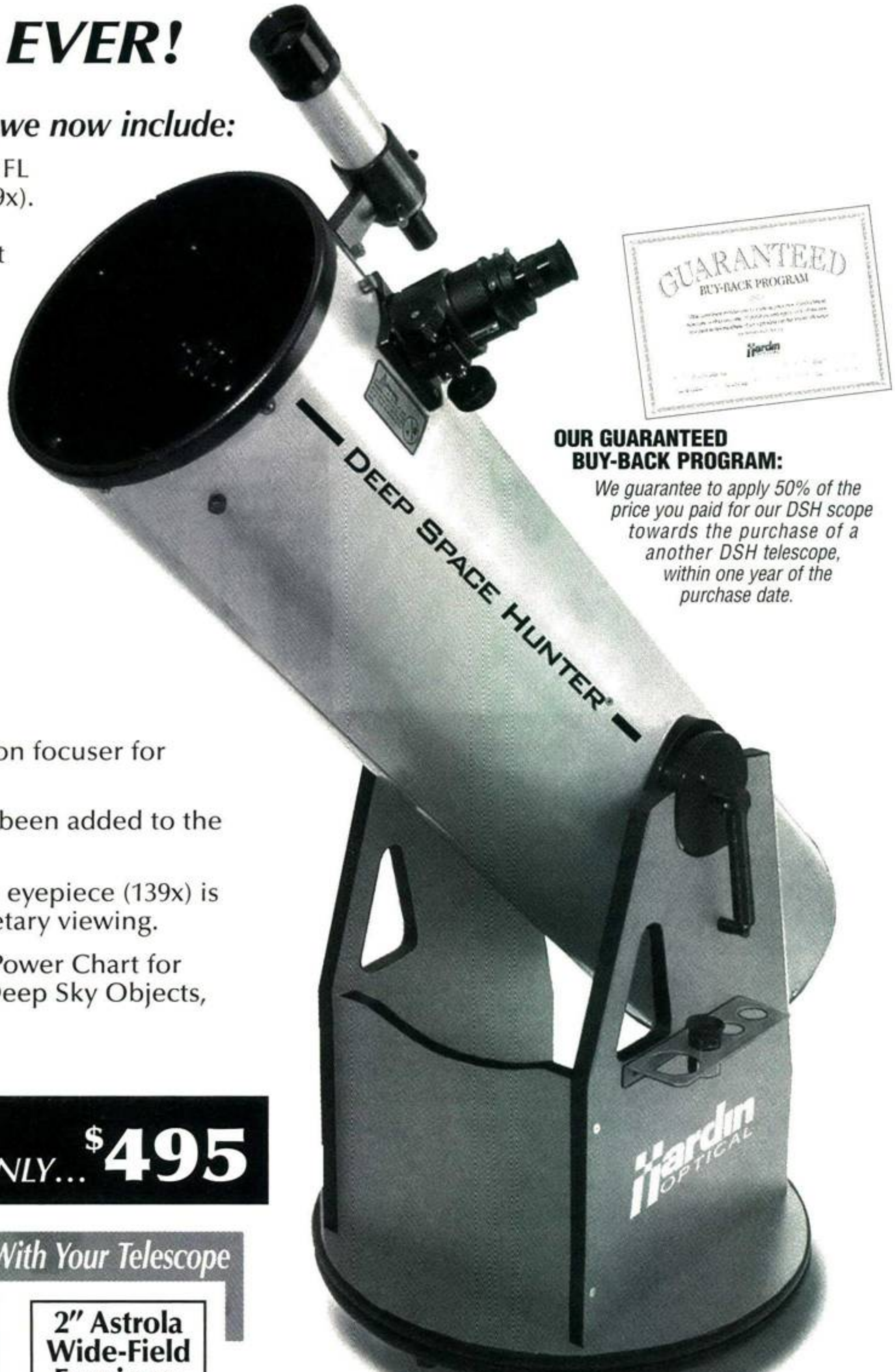

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PLANS FOR CLOSING the Hubble Space Telescope will be submitted by a panel to NASA Headquarters on October 1, 2003. Hubble's mission is set to end in 2010; its replacement, the James Webb Space Telescope, is due for launch in late 2011.

HUBBLE HERITAGE IMAGE

## Magnetic star acts up

**SHREDS OF GAS** hang in space where a supernova exploded in the Large Magellanic Cloud thousands of years ago. The remnant is also a source of x rays and gamma rays. NASA/HUBBLE HERITAGE

Gaseous filaments wrap around a highly magnetized pulsar at the heart of supernova remnant N 49 in the Large Magellanic Cloud, a satellite galaxy of the Milky Way about 160,000 light-years away.

The supernova exploded 5 to 10 thousand years ago in a gigantic blast that was visible from Earth. The debris cloud is expanding at a speed of 340 miles (550 km) per second. Its southeastern edge (upper right in the image) looks somewhat brighter because the remnant is colliding with molecular clouds in the interstellar medium nearby, revealing the remnant's filamentary structure. This interaction is also generating x rays and radio emission.

The original star still survives as a pulsar — a compact, rapidly spinning neutron star that flashes radio energy every eight seconds. It has an enormously powerful magnetic field, a thousand trillion times stronger than Earth's. Astronomers call such objects "magnetars." It appears they are formed in about 10 percent of all supernova explosions.

On March 5, 1979, the pulsar emitted a burst of soft gamma rays, and it has shown several more episodes of activity since. This makes it a "soft gamma-ray repeater." Magnetars emit gamma rays when the solid crust of the neutron star abruptly shifts. The starquake produces an explosion that releases a burst of gamma rays and x rays. **— R. B.**

ASTEROIDS

## Misfit minor planet

**Using a small moon orbiting the main-belt asteroid 22 Kalliope, planetary scientists calculated the asteroid's mass and density. The results call into question a long-held link between Kalliope's classification as a minor planet and a type of meteorite thought to come from that classification.**

**Jean-Luc Margot and Michael Brown [Caltech] used the 10-meter Keck II telescope to image Kalliope and its satellite. The irregular asteroid is 110 miles [180 km] across; its moon spans 22 miles [35 km].**

**Kalliope's spectrum places it among M-type asteroids, long interpreted as the parent bodies of nickel-iron meteorites. But Kalliope's overall density is 2.4 times that of water, while iron meteorites have densities of 7.4.**

**Margot and Brown suggest M-type asteroids include both rocky and metallic bodies. If Kalliope is rocky, it would have a porosity of 30 percent, agreeing with other asteroids. They also mention its unnamed satellite may be an aggregated rubble pile of ejecta born from an earlier impact on Kalliope. — R. B.**

RELATIVITY

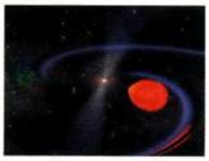
## Gravity waves limit pulsar spin?

How fast can a pulsar whirl? Pulsars with rotational speeds measured in milliseconds speed up by devouring material from a companion star. But can a pulsar pull in enough material to rev up so fast it flies apart?

Apparently not, says a team led by Deepto Chakrabarty (MIT). Using NASA's Rossi X-ray Timing Explorer to observe 11 pulsars that emit bursts of x rays, they found none of the pulsars spin faster than 619 times a second.

Calculations predict that any pulsar will break up when rotation speeds reach 1,000 to 3,000 revolutions per second.

The scientists speculate some process prevents the pulsar's breakup. They suggest faster-spinning pulsars emit more gravitational radiation, which would reduce the energy and place a cap on the spin rate. **— R. B.**

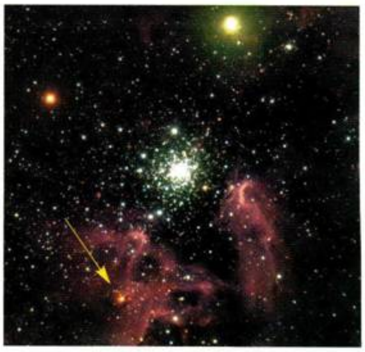


**GAS SWIRLS** onto a pulsar, speeding up its spin. NASA/GSFC, DANA BERRY

STAR FORMATION

## Newborn stars exposed by winds

All stars begin life within clouds of dust and gas. But clouds spawning stars much more massive than the Sun are too dense to show what goes on inside. And massive stars leave infancy before their birth clouds disperse.



**STELLAR WINDS** from a nearby cluster of hot stars revealed a clump of very young, massive stars in IRS 9 [arrow]. ESO

Looking for a way in, Dieter Nürnberger (University of Würzburg, Germany) and colleagues explored knots in a cloud named IRS 9 in NGC 3603, a star-forming region in the Milky Way. They guessed that strong stellar winds from a nearby cluster of hot stars might reveal IRS 9's contents.

Analyzing years of infrared and radio observations told them the knots were indeed protostars, only 100,000 years old and still growing. Moreover, they showed massive stars form the same way low-mass stars do. **— JESSA FORTE NETTING**

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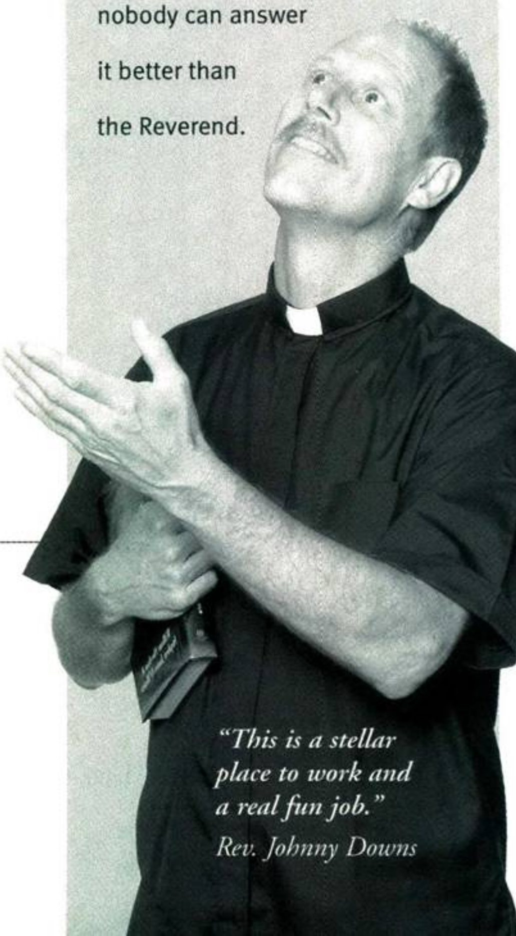

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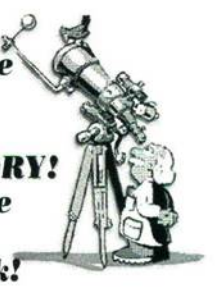

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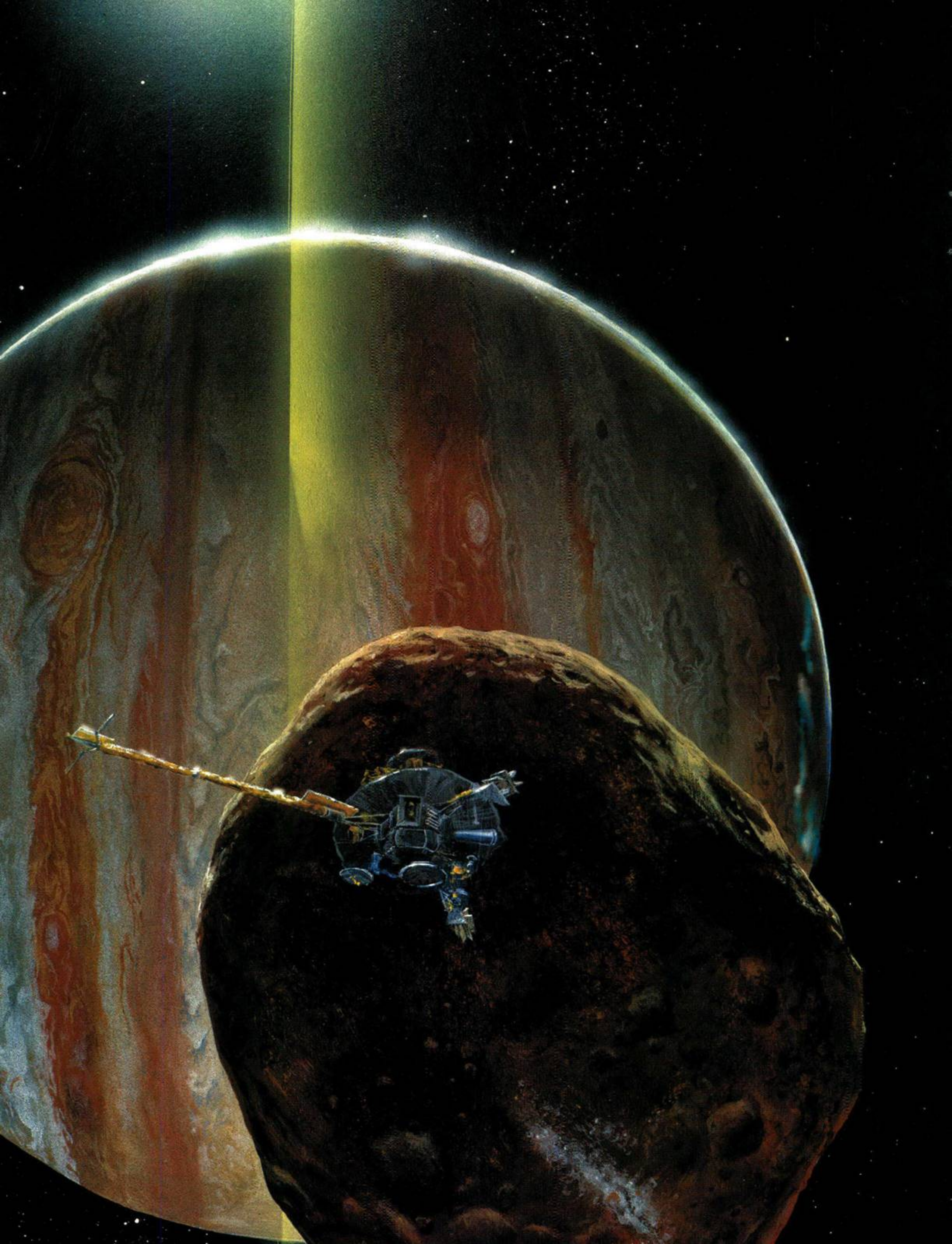


# The long goodbye

Galileo flies past Amalthea in the final science mission of an extraordinary eight-year reconnaissance of the jovian system. /// BY MICHAEL CARROLL

As alien clouds billow up from chasms of swirling fog, a star streaks across the purple sky, trailing sparks and incandescent debris in its wake. This is the end of Galileo, an ambitious and incredibly successful mission of discovery. Since 1995, the Galileo spacecraft has orbited Jupiter, charting its moons, sampling its magnetic field, and weathering a constant storm of radiation. Even in its last loop around Jupiter, the craft continued to be remarkably productive, with a scientifically surprising flyby of the inner moon Amalthea. The dramatic conclusion to its illustrious mission, slated for September 21, 2003, will culminate with a suicide dive into the jovian clouds.

At its launch in 1989, no one anticipated such an end. Long before the 3-ton explorer first swooped past Jupiter's innermost large moon, Io, mission planners knew they faced trouble. A main antenna that never unfurled properly sent flight engineers scrambling to get a fire hose of science data through a soda straw of the tiny, omni-directional antenna designed for low data rates. But the plucky Galileo, battered by micrometeorites, seared by deadly radiation, and hamstrung by its folded antenna, just wouldn't die. Living years beyond its design life, the craft flew extended missions to further explore Jupiter's most intriguing moons: Io and Europa. In all, Galileo completed 38 flybys of various planets (Earth twice and Venus once), asteroids (Gaspra and Ida), and Jupiter's four large moons.

The data Galileo collected have yielded tantalizing hints of a global ocean hidden beneath the frozen surface of Europa. Due to the possibility — no matter how remote — that life might have gained a foothold in the suspected subsurface ocean, mission planners decided to target the craft for a destructive plunge into Jupiter. This avoids even the slim chance of a contaminating impact with the icy moon.

Galileo's discovery of Europa's global sea was one of many hard-won revelations of its long mission. "From the beginning, we had to overcome challenges," says Galileo Project Manager Eilene Theilig. "One of the greatest challenges was that we had to use a tiny omni-directional antenna [instead of the umbrella-like high-gain antenna], and we were still able to make incredible discoveries." The mission's strategy hinged upon the use of an onboard tape deck to record incoming data for the painfully slow playback later. But the tape recorder endured massive doses of radiation, far beyond its design. The radiation gave flight engineers constant problems with the recorder, not the least of which would come at a critical time in the mission's very last encounter.

## Meeting a moonlet

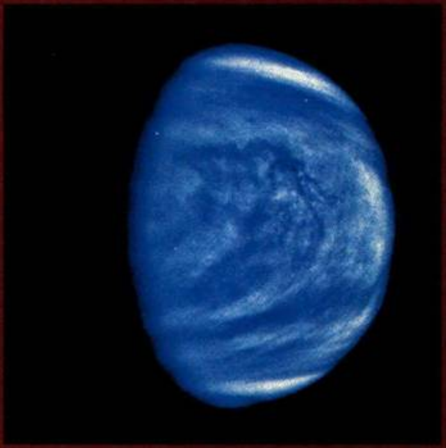
Jupiter's environment had taken its toll on Galileo when, early last year, the final orbit was about to begin. High radiation deep inside Jupiter's magnetosphere already had caused the computers to abort several encounters with volcanic Io. Now, as the craft commenced its final loop of Jupiter, analysts realized this last orbit afforded an opportunity to fly near one of the planet's small inner moons, Amalthea.

"Amalthea is unique because of its proximity to Jupiter, its small size, and its irregularity," says John Anderson, Senior Research Scientist at NASA's Jet Propulsion Laboratory (JPL). "It's an inner moon and largely unexplored. It's a small body orbiting so close to Jupiter that we knew it must be interesting."

Anderson leads the Gravity Science team on the Galileo project, and it was gravity that would reveal Amalthea's secrets. By monitoring subtle changes in the velocity of the spacecraft, scientists could tell how much gravity the tiny moon exerted on Galileo's flight path. Those velocity changes would, in turn, shift the radio signals coming from the craft, much as the tone of a car horn changes as it approaches and recedes. "We realized we could determine something about its mass with this encounter," says Anderson. "We already knew its volume, so we needed its mass to determine its density. We'd been doing this type of gravity study with the Galilean satellites, so we knew we had a good system."

**WHEN GALILEO VISITED AMALTHEA** last November, it braved the most intense radiation of the entire mission to measure the small moon's density and sample its environment. PAINTING BY MICHAEL CARROLL

**GALILEO'S LONG VOYAGE** began when it was deployed from the cargo bay of the space shuttle Atlantis on October 18, 1989. NASA



**CLOUD-COVERED VENUS** was Galileo's first target. The spacecraft flew past the planet four months after launch to pick up needed speed. NASA/JPL

**SOUTH AMERICA POSED** for Galileo on December 11, 1990, during the first of two Earth flybys that further increased the spacecraft's velocity. NASA/JPL

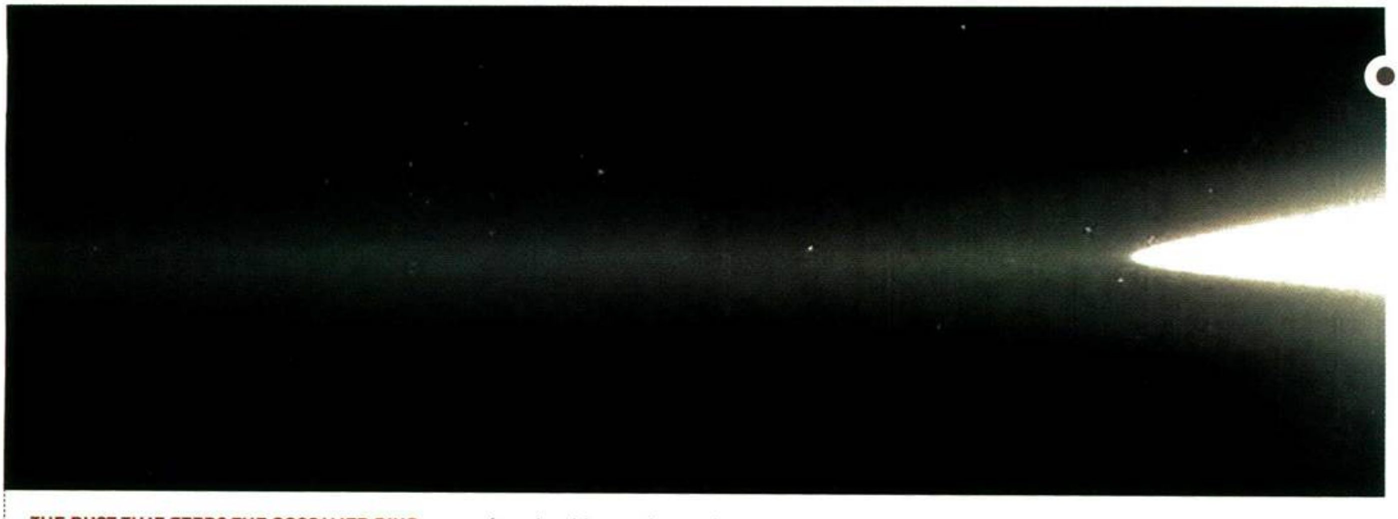
Theilig saw other reasons for visiting the tiny moon. "Amalthea was an important target. First, Galileo had not flown close to any minor moons. It is clear that the ring material originates from the inner moons, so not only would we understand Amalthea, but we would also learn something about the material in the ring system as well. Second, if the small moons had condensed out of the jovian nebula they'd be more dense [than the larger Galilean moons]. That was something that only a close flyby could tell us."

But the encounter would take place under daunting conditions. Radiation had drastically affected Galileo's carrier signal, the radio heartbeat that could show subtle shifts in velocity. And the radiation at Amalthea — orbiting halfway between Jupiter and Io — would be higher than at any other time in the mission. Theilig was up to the test. "At Amalthea, the challenge was to bulletproof the sequence, to make the data gathering process robust. We created a contingency sequence that would be kicked off if the spacecraft went into safe mode. We changed the fault protection. We looked at our experiences and worked around the problems that we'd had in the past."

Even if the spacecraft could be programmed to survive Jupiter's intense energy fields, flight engineers had another problem. Trajectory engineer Tony Taylor explains, "Our biggest challenge was to get close enough for good gravity data without risking impact. We were constrained by two limits: We needed to be within 300 kilometers (180 miles) for good science, but we also needed to avoid impact. Our trajectory gave us a 0.15 percent probability of impact."

Amalthea's irregular shape complicated the flight path. The potato-shaped moon measures 91 miles (146 km) across and 163 miles (262 km) long. Like all tidally locked moons, it keeps the same face toward Jupiter, with the long axis pointing directly at the planet's center. The irregular shape meant Taylor's team had to know which way the moon was pointing relative to the spacecraft's location at all times. "We were dealing with the geometry of the flyby angle combined with the shape of Amalthea," says Taylor. "I had fun with it. It was technologically challenging."

Engineers also were constrained by the fact that at the end of this last orbit, Galileo had to line up with mighty Jupiter as its



**THE DUST THAT FEEDS THE GOSSAMER RING** comes from Amalthea and two other small moons, Metis and Adrastea. In this early Galileo image, the tenuous material of the Gossamer Ring stretches from the main ring at right to the left edge and beyond. NASA/JPL

**ASTEROID GASPRA** became the first such object viewed up close in October 1991, when Galileo ventured into the asteroid belt. NASA/JPL

**THE MOON'S NORTH POLE** — never seen clearly from Earth — showed off for Galileo during the craft's second Earth flyby in 1992. NASA/JPL

**GALILEO PHOTOGRAPHED DACTYL** [right], a tiny moon orbiting the asteroid Ida, in August 1993. It was the first such moon to be discovered. NASA/JPL

final resting place. Because Amalthea circles the planet twice each day, many flyby opportunities were available. The team chose a trajectory, and the craft was commanded to dive deep into Jupiter's deadly environment for one last pass.

On November 5, 2002, Galileo sailed past the little moon. The craft's targeted altitude was 74 miles (119 km). Taylor and his team were pleased with the journey. "We passed about 30 km (20 miles) outside of the aim point; that's a successful trajectory!"

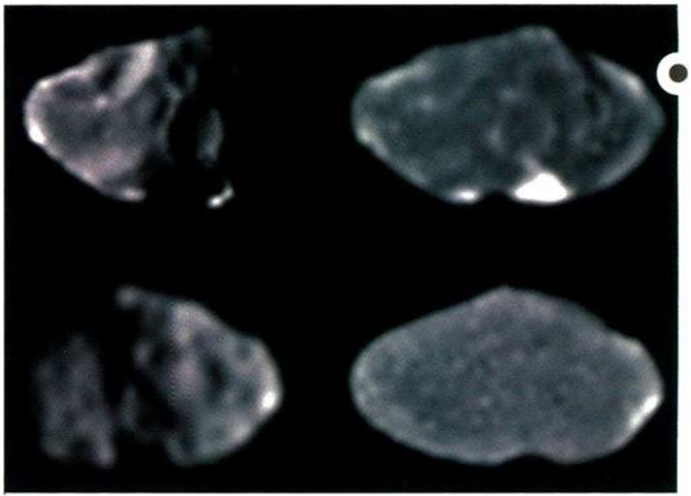
Although the flight path was just what the science team needed, it became apparent that other things had gone awry. "Just about everything that could go wrong did go wrong," quips Taylor. "We were depending on a two-way link [to see subtleties in the Doppler shift], but the two-way feedback loop was never established." Normally, for navigation purposes, scientists on Earth send a precise signal to the spacecraft. The spacecraft locks to it and sends it back. The ratio between the frequency of the uplink and downlink signals gives a very accurate measure of the Doppler shift. Instead, engineers had to rely on the spacecraft oscillator, which radiation affects. Taylor explains, "The signal cycle on the spacecraft drifts [with temperature change and energy fluxes from Jupiter], so it's not as accurate."

"The day after encounter, people were down in the dumps," says Science Team Leader Torrence Johnson. "We thought we had lost everything but the real-time data." And there were more problems. Despite Theilig's "bulletproofing," the spacecraft went into safe mode about 16 minutes after closest approach to Amalthea. "The science sequence stopped because of a specific kind of fault. We had seen this fault before but could not safely work around it," she said. Theilig got even more bad news. After the encounter, something failed in the tape recorder. "Before the encounter, the closest the craft had been to the planet was a distance of 4 jovian radii [from the center of the planet]. This time, we flew inside 2.5 radii and were able to sample the Gossamer Ring. And we had all the Amalthea data, too. That's what was so frustrating — knowing all that data was trapped on the recorder." Would the precious contents ever be seen?

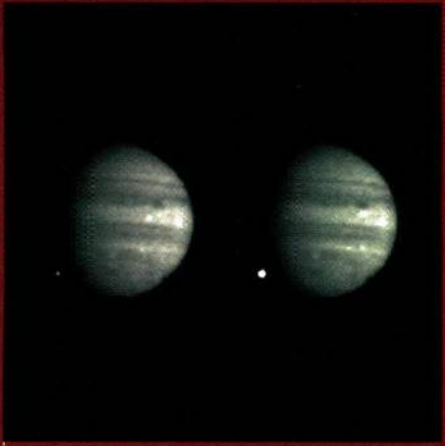
Researchers immediately went to work. After coaxing the craft out of safe mode, they spent weeks sifting through the data.

### /// FINDING FAULT

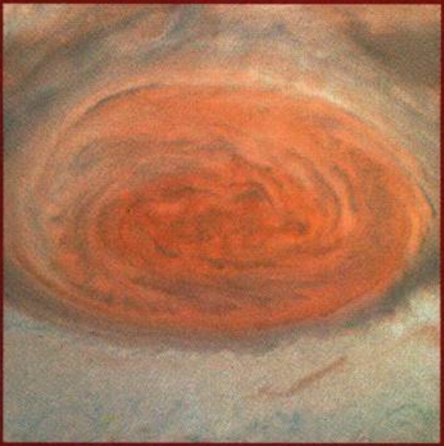
Galileo's computers carry sophisticated programming called "fault protection" to safeguard the mission in the event of failures. With one-way radio delays up to 40 minutes, the craft is on its own in a crisis. In order to monitor its own health, Galileo's computers constantly check each other. "Any computer has a heartbeat, an internal cycle," explains Science Team Leader Torrence Johnson. "When different parts of the command control system don't agree, the computer assumes that something is wrong. It's called a parity error." At Amalthea, Jupiter's fierce radiation caused the spacecraft's internal clocks to lose time, and the cycles did not agree. The computers went into "safe mode" to protect the spacecraft from further harm. "We've spent six years developing [Galileo's newest fault protection] and three years of changing and tweaking it to fit new anomalies." Although this helped reduce the number of safe modes Galileo would have experienced otherwise, scientists still lost significant chunks of data, for example, during the Amalthea flyby.



**AMALTHEA LOOKS LIKE A POTATO** in these Galileo images from earlier in the mission; the camera was turned off during the recent flyby. NASA/JPL



**WHEN COMET SHOEMAKER-LEVY 9** smashed into Jupiter in July 1994, Galileo got the only direct look at a resulting fireball. NASA/JPL



**THE GREAT RED SPOT**, a gigantic high-pressure system in Jupiter's atmosphere, shows exquisite detail in this Galileo true-color image. NASA/JPL

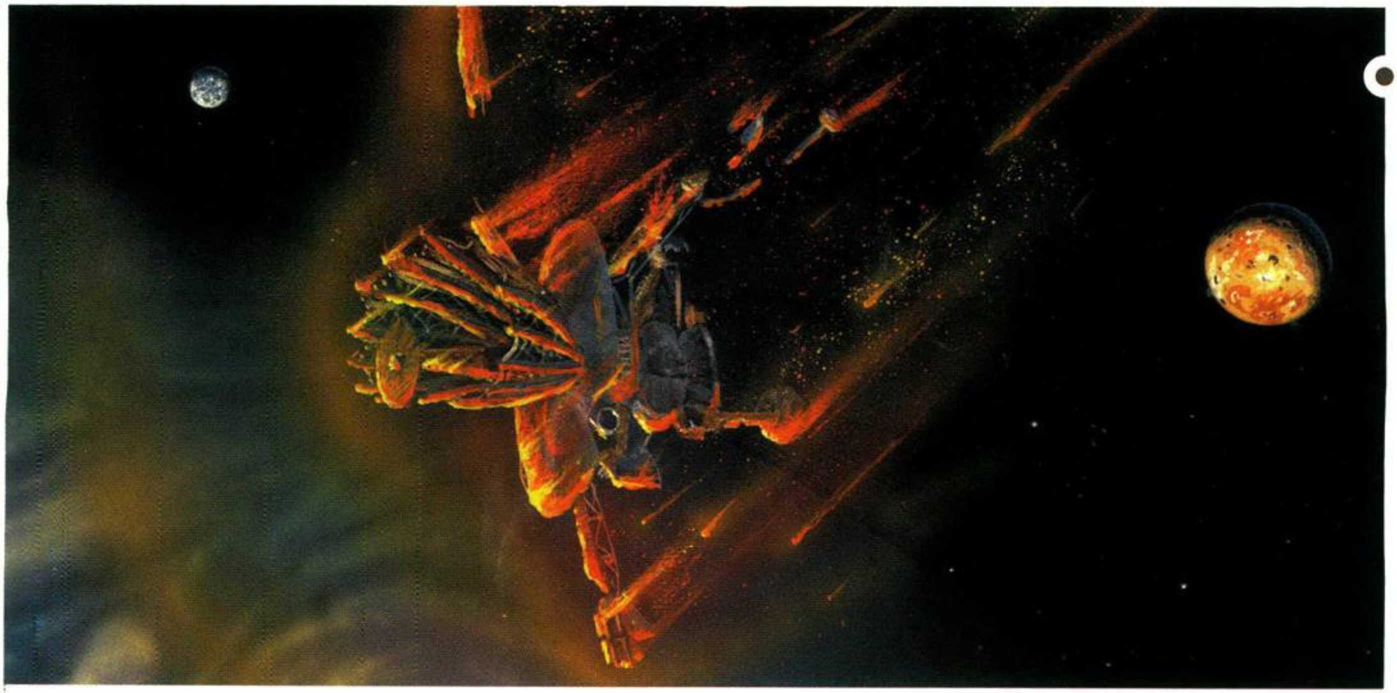
**VOLCANIC ERUPTIONS WRACK IO**, Jupiter's innermost big moon. Galileo observations show it may have as many as 300 volcanoes. NASA/JPL

Finally, the diagnosis was made: The optical electronics in the mechanism that drives the recorder's motor had been damaged by radiation. Galileo, now 423 million miles from Earth, was in need of a long-distance repair. To fix the problem, the recorder's tiny sensors needed to be annealed, or tempered, by alternate heating and cooling. "We applied current to the LEDs to anneal them," explains Theilig. "The real story of the Amalthea encounter was turning potential failure into success. That's really the legacy of the entire Galileo mission."

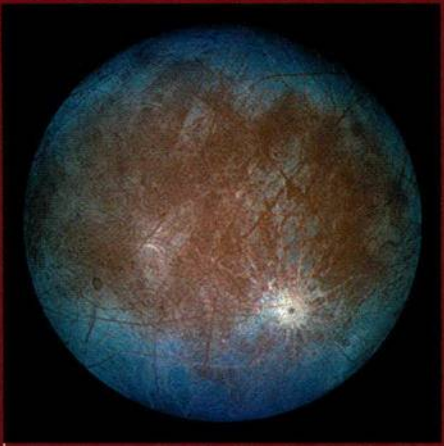
Anderson's team had to change its approach in measuring the signal shift. "Two-way communication would have given us structure in the gravity field around the moon, but we did get the mass, and that was significant because Amalthea has no close interaction with other satellites to give us clues. With the new mass figures, coupled with the known volume, we could model the internal structure."

The trajectory team's results were startling. "We expected three times the density of water, but what we were getting from the data was one-third that. At first, we thought something was wrong with the science data." But the data were accurate. Anderson began to assemble a picture of a strange moon made up of rubble.

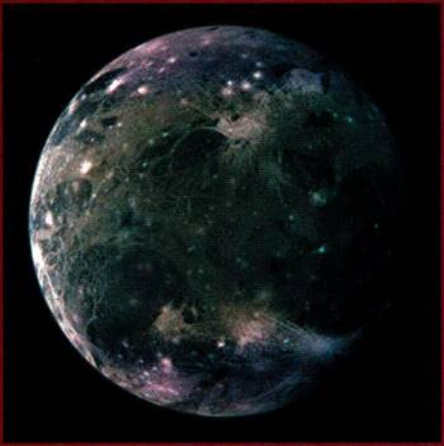
"I didn't expect the low density. I expected the density of rock, about 3 to 3.6 times the density of water. Instead, we got a density a bit less than water. We're knocking around a porous model — loosely packed rock with perhaps some ice trapped inside." The few distant images Galileo took during earlier orbits gave no hint of Amalthea's internal structure. Scientists saw irregularities in the



**GALILEO WILL BURN UP** in Jupiter's atmosphere this September, when it slams into the giant planet's cloudtops at 30 miles/second. PAINTING BY MICHAEL CARROLL



**EUROPA'S GLOBAL OCEAN** of liquid water — discovered by Galileo — lurks under an icy surface that displays numerous cracks. NASA/JPL



**GIANT GANYMEDE**, the largest moon in the solar system, shows frosty polar regions, bright, grooved terrain, and dark, furrowed areas. NASA/JPL

**POCKMARKED CALLISTO** is the most heavily cratered object in the solar system. The bright scars represent more recent impacts. NASA/JPL

surface, but not gaps. Any gaps would be filled in by regolith, the dusty coating blanketing the surface.

Johnson finds the implications of Amalthea's low density intriguing. "The moon is barely holding together. At the ends, rotational and gravitational forces are right at the limit of tearing it apart." In fact, Johnson estimates the escape velocity at the tips of Amalthea to be about 1 centimeter/second. "Nudge a piece of gravel, and it's gone." Galileo actually detected debris floating in Amalthea's neighborhood. At least seven objects, which may range in size from gravel to "stadium sized," were glimpsed by the spacecraft's star tracker, says JPL engineer Paul Fieseler. "It is likely that these bodies either have been gravitationally captured into an orbit near Amalthea or have been split off of the moon," he says.

In addition to these revelations about Amalthea, Galileo returned data that helped chart the structure of the Gossamer Ring. Amalthea orbits within this ring, and Galileo sustained thousands of "hits" from ring particles both outside and inside the moon's orbit. Researchers had already determined that the rings were fed by dust streaming from at least three minor moons: Amalthea, Metis, and Adrastea. According to Johnson, "Several satellites contribute to the Gossamer Ring. Its thickness is determined by their orbital inclination, so that the farther the satellite is inclined to the ring plane, the thicker the ring material is above and below the plane." The data are still being studied.

## The end of an era

Galileo has weathered a host of hardware and natural obstacles and still returned data on dozens of encounters with Jupiter and its moons. But the craft is quickly running out of maneuvering fuel. Soon, it will be impossible to control the explorer, so the time has come to retire it safely into the atmosphere of the king of worlds. But before the end, Galileo has one final scientific act to perform, says Theilig. "Nineteen hours before impact will be the last science gathering. Galileo will be sending real-time data on the fields and particles of Jupiter's magnetosphere until the spacecraft disappears behind the planet [as viewed from Earth]."

At the moment the craft disappears from Earth's view, it will be 5,768 miles (9,283 km) above the 1 bar reference level, the depth in the atmosphere equal in pressure to Earth at sea level. Because Jupiter has no solid surface, this is the standard reference — as close to "sea level" as one can get on a gas giant. A few minutes after Jupiter blocks Galileo from view, the craft will sear through the planet's upper atmosphere, vaporizing at 30 miles/second (48 km/sec).

Tony Taylor's flight path will take the craft to its final resting place. "Galileo's end has drama and finality to it — it's sort of a poetic end. It goes to rest where its main mission was defined. I feel like it had a good run. The spacecraft did what it was supposed to and even more."

In fact, it is Galileo's longevity that many will remember, including Anderson. "I was surprised that we got 34 productive orbits. After all, we had a crippled spacecraft (with its failed main antenna), but we managed to have a successful mission."

Eilene Theilig has mixed emotions about the end of the Galileo mission. "There is sadness for the final farewell, but at the same time, there's a sense of celebration for what the mission and project have done."

Like Theilig, Torrence Johnson was on the ground floor of Galileo's conception during the early Voyager encounters. "It's funny, but I don't tend to anthropomorphize these things. I've regarded the mission as an extension of our own senses. I have an overwhelming feeling of satisfaction. Also, Galileo laid the foundation for other projects, like the upcoming [Cassini] Saturn mission and the proposed Jupiter Icy Moons probe."

It is this continuum, this flow of knowledge, that gives Galileo its truest meaning. After rising above seemingly impossible obstacles, Galileo leaves a legacy of knowledge as it coasts toward its final, fiery end in the clouds of Jupiter.

**Michael Carroll** *lives in Colorado, where he frequently writes and paints for* Astronomy. *His science books for children include* Spinning Worlds; Dinosaurs; *and* Exploring Ancient Cities.

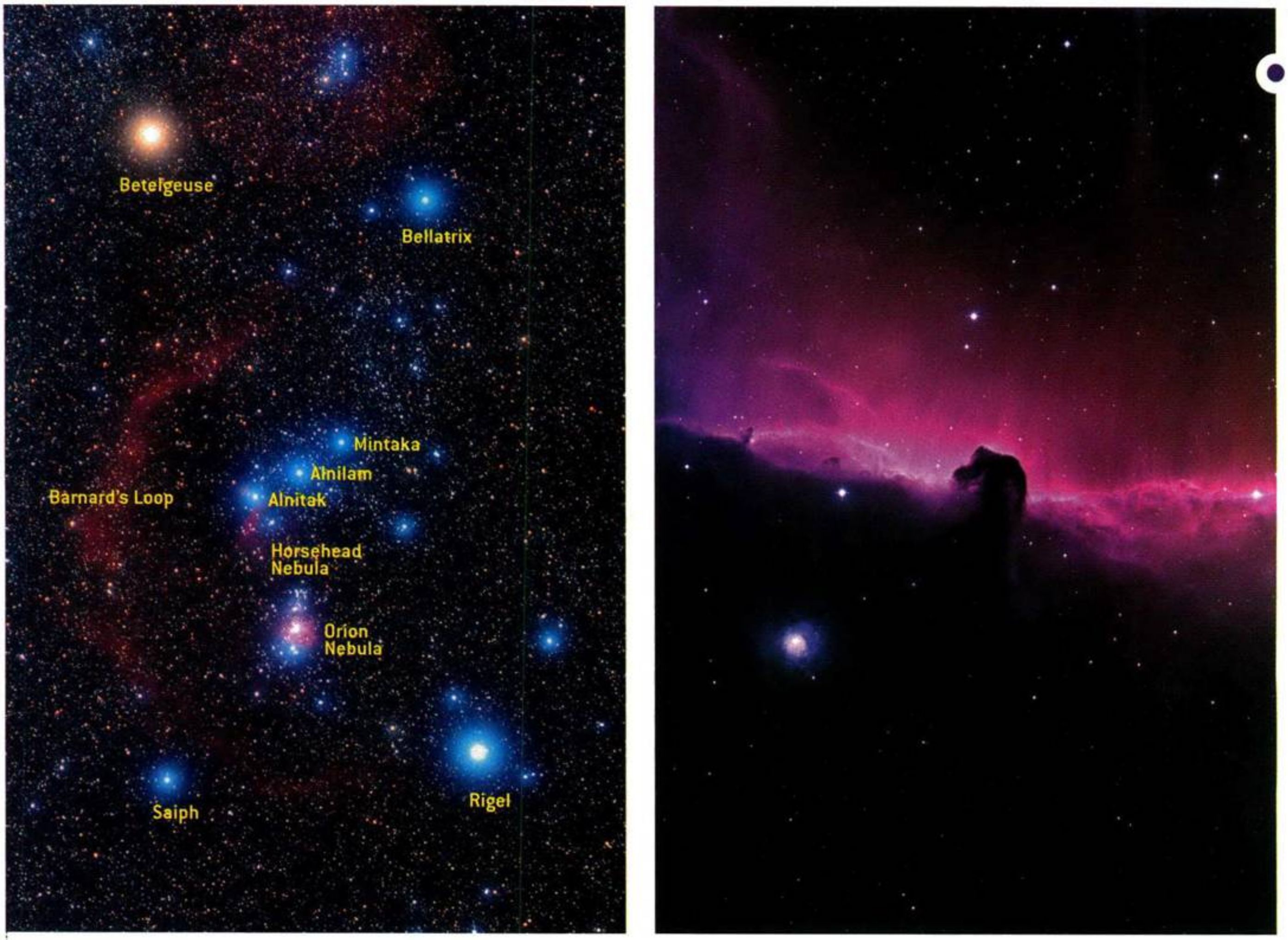
To learn about the proposed Jupiter Icy Moons Orbiter mission, visit www.astronomy.com/toc

# Style & substance

A resplendent gem in the eyepiece, the Orion Nebula is not just another pretty face. It may hold the key to how stars and planets form. /// BY RAY JAYAWARDHANA

Orion the Hunter is a familiar constellation in winter's evening sky. A little below the three stars that make up the Hunter's belt, near the middle of his sword, shines a giant cloud of gas and dust known as the Orion Nebula, illuminated by several hot stars that make up the famous Trapezium Cluster at its core. The nebula's beauty — not to mention its scientific mysteries — has long mesmerized both amateur astronomers and professionals. In the past two decades, researchers have published nearly a thousand papers on the nebula, which, at a distance of about 1,500 light-years, is the closest stellar nursery harboring massive stars.

**THOUSANDS OF STARS,** some of which may host planets, condense from gas in the billowy Orion Nebula. Three observers using 7- to 10-inch Astro-Physics telescopes combined their 30-minute color and 70-minute Hα exposures to make the composite at right. TRENT KJELL, MARK JENKINS, AND ROLAND CHRISTEN



**THE ORION NEBULA** forms part of a giant complex of gas and dust that includes Barnard's Loop and the Horsehead Nebula (right) and lies 1,500 light-years away in the constellation Orion. *LEFT:* BILL AND SALLY FLETCHER; *RIGHT:* T. A. RECTOR (NOAO/AURA/NSF) AND HUBBLE HERITAGE TEAM (STScI/AURA/NASA)

The Orion Nebula, also called M42, is a thin, concave blister of hot, ionized gas in front of a vast molecular cloud complex that drapes across much of the constellation Orion. Most of the cloud is extremely cold and dark, made up of hydrogen molecules (hence the name "molecular cloud") and a smidgen of dust. Newborn stars ionize and illuminate M42 and other well-known landmarks such as the Horsehead Nebula and Barnard's Loop.

Oriented nearly face-on to us, the nebula lies behind a cavity carved out by the hot young stars of the Trapezium and their brethren. In the foreground, a thin veil of interstellar gas and dust appears as the "dark bay" to the east of the Trapezium stars.

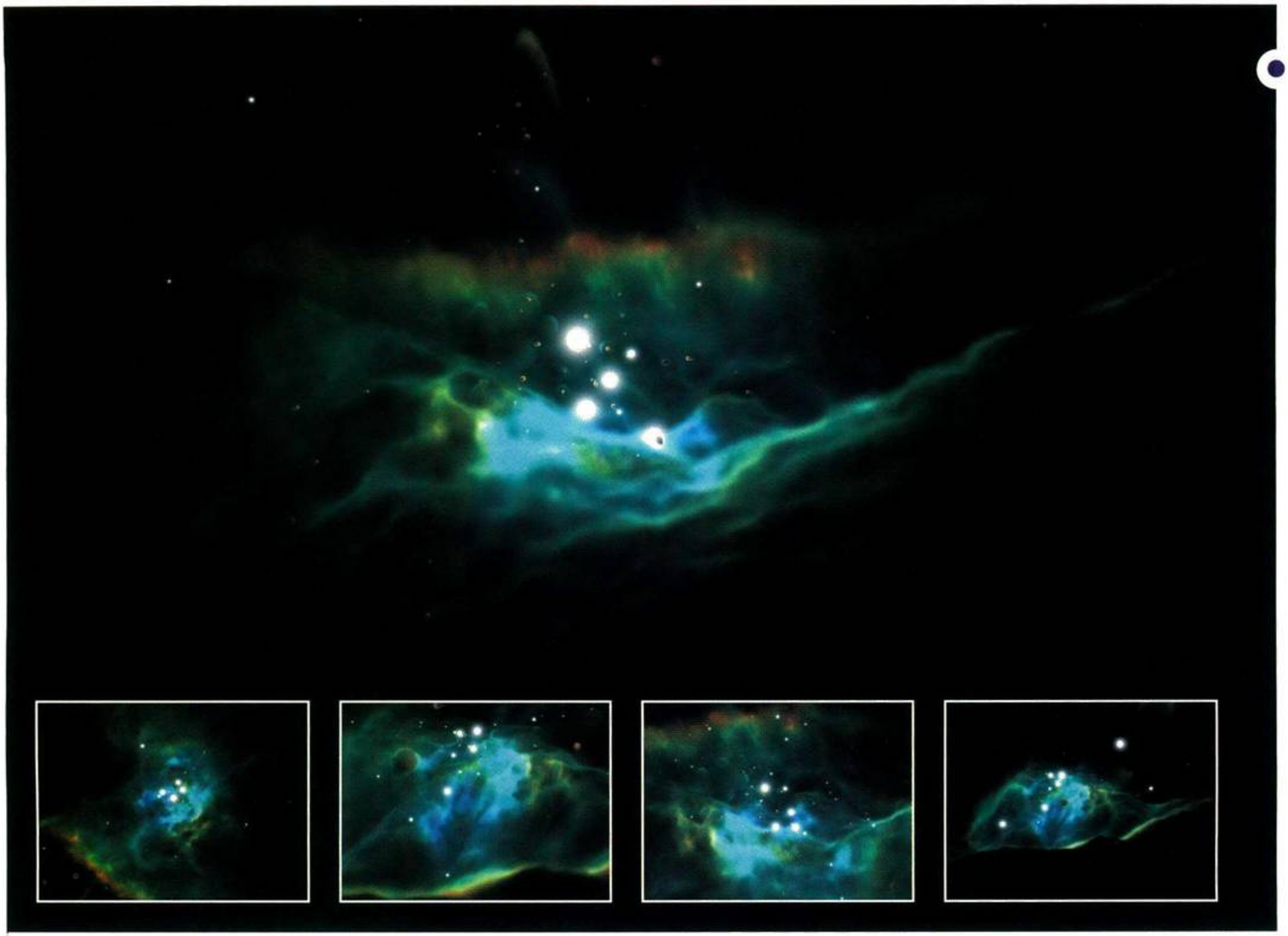
In the 1990s, C. Robert O'Dell and Zheng Wen, both then at Rice University, produced a detailed model of the nebula based on a variety of observations. A few years ago, computer graphics experts at the San Diego Supercomputer Center used the model to create a stunning 3-D visualization of M42 for New York's Hayden Planetarium at the American Museum of Natural History.

**Ray Jayawardhana** *is a contributing editor and an astronomer at the University of Michigan. He studies the disks around young brown dwarfs using many of the world's largest telescopes, including the Kecks and Subaru.*

In the nebula's blazing heart, about 3,000 very young stars, most less than a million years old, crowd into a volume just a few light-years across. Only a few of the brightest penetrate dust in the natal cloud to shine through as the Trapezium Cluster. But detectors sensitive to infrared or x-ray wavelengths pierce the dust to reveal the majesty of thousands of young suns.

When the Hubble Space Telescope imaged the Orion Nebula in 1992, the silhouettes of dusty disks around many baby stars stood out against the nebula's bright background. Because dust absorbs a star's light and re-emits it as infrared radiation (heat), stars with disks glow more brightly in the infrared than do diskless stars. Surveys of nearby star-forming regions such as the Trapezium Cluster previously had revealed that 50 to 80 percent of newborn stars harbor an "infrared excess" consistent with the presence of disks. But it was reassuring to see the disks directly with Hubble.

These disks are typically a few hundred astronomical units across, or several times the size of Pluto's orbit around the Sun, and their masses range from about 1 to 10 percent of the Sun's mass. That's more than enough stuff to make a planetary system like ours. But many of the disks won't survive long enough to grow planets; intense ultraviolet radiation from hot stars in the Trapezium boils off material from the surfaces of many of these protoplanetary disks, or "proplyds."



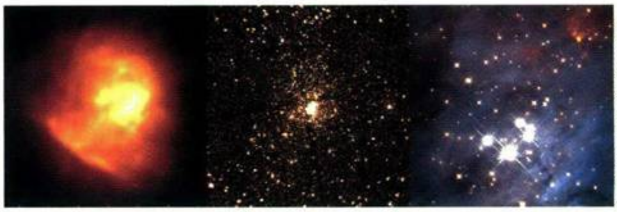
**A 3-D FLYBY MOVIE** of the nebula was painstakingly made from about 31,000 high-resolution rendered images for New York City's revamped Hayden Planetarium. AMERICAN MUSEUM OF NATURAL HISTORY, SAN DIEGO SUPERCOMPUTER CENTER, AND DIGITAL GALAXY PROJECT

Hubble images show a comet-like coma of evaporating material cocooning each proplyd, the coma's tail pointing away from nearby hot stars. The disks are losing material at the furious rate of about a half-Earth mass per year. They will evaporate completely within a few hundred thousand years, probably before planets will have had a chance to form. Living so close to the Trapezium's bigwigs presents "an environmental hazard to planet formation," as astronomer John Bally of the University of Colorado in Boulder puts it.

Space- and ground-based telescopes also show pairs of long, thin jets emanating from some very young stars. Twisting magnetic field lines send a fraction of the material that spirals toward the star from the disk hurtling into space along jets perpendicular to the plane of the disk. Many of the jets contain clumps, suggesting that material is being shot out in machine-gun-like fashion every few decades. Since the origin of the jets is intimately linked to infalling material from the disk, the presence of clumps implies the material falls onto the star in spurts.

Moving at hundreds of thousands of miles per hour, the jets slam into the surrounding interstellar gas, creating a bow shock similar to that made by a speedboat skimming across a lake. The violent collision heats up the stationary gas, and the result is glowing shock regions known as Herbig-Haro objects, after George Herbig and Guillermo Haro who discovered them in the 1950s.

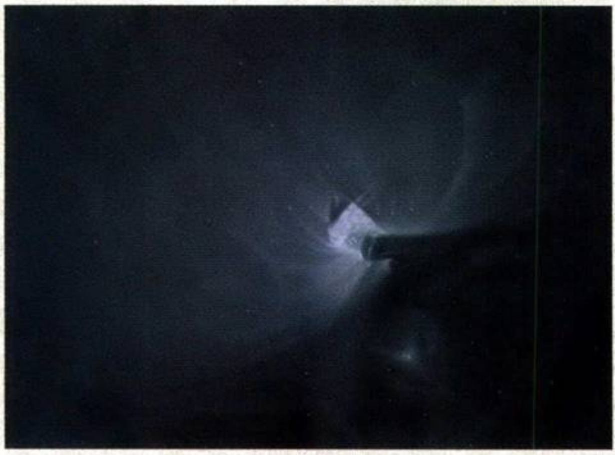
## /// THE ORION NEBULA'S MANY FACES



Instruments that detect different wavelengths reveal different properties of the multi-faceted Orion Nebula. *Left*: The large, cold outflows in which high-speed jets are buried show up best in radio images. *Center*: X-ray images expose about a thousand x-ray sources in the nebula, most of which are young stars that emit more high-energy radiation than older stars due to their stronger magnetic fields. The Chandra X-ray Observatory penetrated the dense Orion Molecular Cloud to resolve, for the first time in these wavelengths, massive stars still nestled in their mother clouds. About a dozen x-ray sources in this image have no known optical counterparts, and three sources appear to be the size of brown dwarfs. *Right*: Infrared wavelengths also pierced the obscuring clouds of gas in the nebula to reveal about 50 brown dwarfs in this Hubble view centered on the Trapezium Cluster. The brown dwarfs are too dim to be seen in optical light.

LEFT: NRAO (VLA AND GBT); CENTER: NASA/PSU; RIGHT: NASA; K. L. LUHMAN (CfA); G. SCHNEIDER, E. YOUNG, G. RIEKE, A. COTERA, H. CHEN, M. RIEKE, AND R. THOMPSON (STEWARD OBSERVATORY)

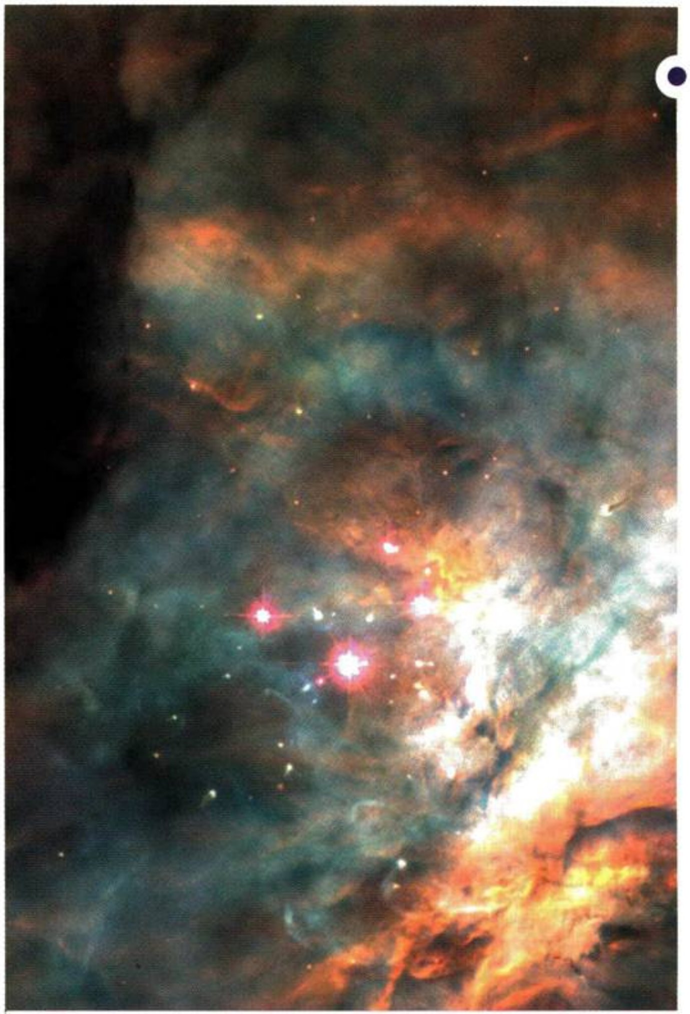
### /// OBSERVATIONAL MILESTONES



COURTESY JOHN G. WOLBACH LIBRARY, HARVARD COLLEGE OBSERVATORY

Under good sky conditions, the Orion Nebula is visible to the naked eye as a fuzzy patch, but no records of it exist before the advent of telescopes. In 1609, Galileo cataloged stars in the region, but not the nebula. French lawyer Nicholas-Claude Fabri de Peiresc evidently first spotted it with his telescope a year later. In 1654, Giovanni Batista Hodierna of Italy included the first known drawing of it in a catalog.

In the following two centuries, a string of famous observers, including Christiaan Huygens and William Herschel, carefully studied it. Charles Messier included it as the 42nd object (M42) in his catalog of nebulae so that it would not be mistaken for a comet. Herschel's description of it as "an unformed fiery mist, the chaotic material of future suns" sounds prophetic given what we know today, but his claim that the nebula's appearance changed over a period of several years is probably spurious. In the years before his death in 1865, George Bond of Harvard College Observatory produced one of the most beautiful drawings of the nebula ever made (above). In 1880, Henry Draper first photographed it using an 11-inch scope. — *R. J.*

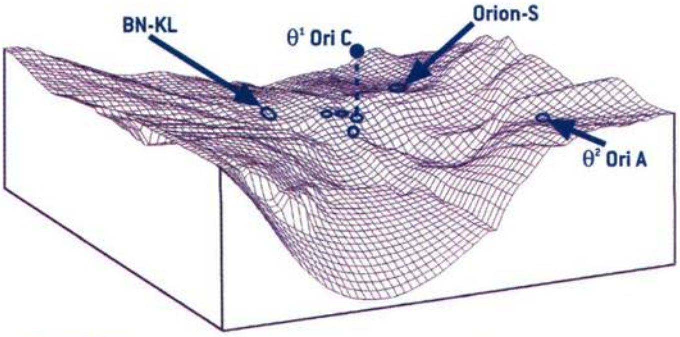


**THE TRAPEZIUM CLUSTER STARS** at the heart of the Orion Nebula ionize the surrounding gas, making it glow. NASA, C. R. O'DELL, AND S. K. WONG (RICE UNIVERSITY)

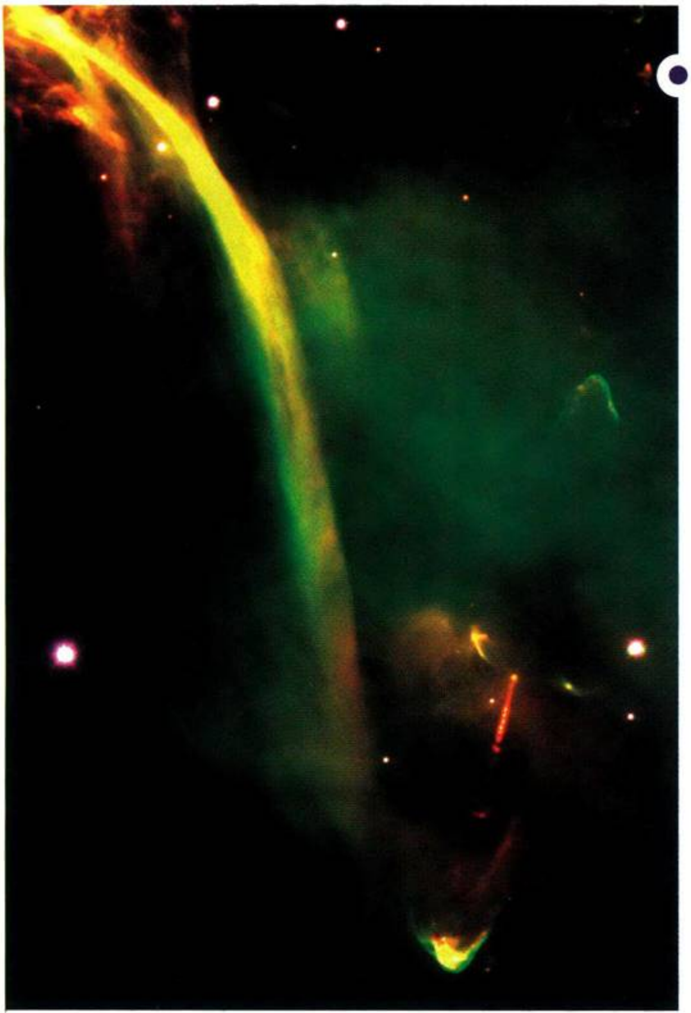
In addition to the jets, which are narrow, hot, and fast-moving, some young stars harbor broader and slower outflows of cold gas. The jets are usually nested inside these vast outflows. While the ionized gas in jets can be seen in optical and near-infrared images, the colder outflows are best detected through the emission of specific molecules at radio wavelengths.

When the Chandra X-ray Observatory took a long exposure of the Orion Nebula recently, it came up with a rich bounty — thousands of young stars glowing more brightly in x rays than our middle-aged Sun. These x-ray powers, as well as observations of flares much stronger than those on the Sun, are probably the result of elevated magnetic activity due to the stars' youth. "We found a much higher rate of flares than expected," says Eric Feigelson of Pennsylvania State University. In fact, the flares are energetic and frequent enough that if the Sun had experienced such flares in its past, they could account for the creation of unusual isotopes found in ancient meteorites. "If the young stars in Orion can do it, then our Sun should have been able to do it too," argues Feigelson.

Although a few massive, hot stars dominate the Trapezium, the vast majority of objects in the Orion Nebula are less massive than the Sun. Some of these bodies are too puny to fuse hydrogen at all. These failed stars, with masses below 75 Jupiters, are known as brown dwarfs and glow only by converting gravitational energy into heat as they slowly contract in size. A recent, deep-infrared

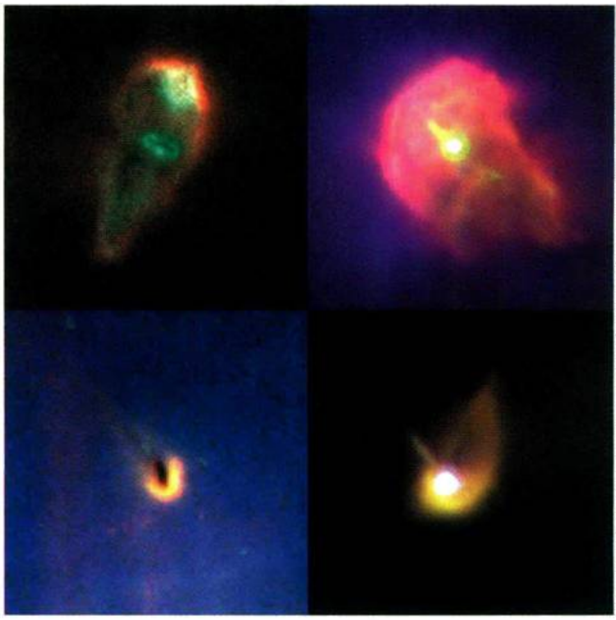


**NEBULOUS** though it may be, M42 has an observed shape. As viewed from the northeast, theTrapezium Cluster's four major stars (center), including the brightest, $\theta^1$ Orionis C, are projected onto the surface of surrounding gas in this model. Also shown are the BN-KL complex of stars, the protostar Orion-S, and the nearby star $\theta^2$ Orionis A. C. R. O'DELL (VANDERBILT UNIVERSITY)



**HERBIG-HARO 34** is the dark object capped by bright shock regions to the right of a mysterious "waterfall" of gas in the Orion Nebula. ESO/VLT/FORS2

## /// BIRTHPLACE OF NEW PLANETS?



NASA, J. BALLY (UNIVERSITY OF COLORADO, BOULDER), H. THROOP (SOUTHWEST RESEARCH INSTITUTE), AND C. R. O'DELL (VANDERBILT UNIVERSITY)

Protoplanetary disks, or proplyds, girdle many young stars in the Orion Nebula. Dust in the disks may clump together to create planets, but the would-be planets are in a race against time — radiation from nearby massive stars tends to boil away the disks in about 100,000 years, a time span generally considered too short for planets to form. The Hubble Space Telescope has imaged proplyds in the nebula since 1992, revealing their hallmark shape. Each star and its disk are swaddled in a bubble of gas from which they collapsed. Particles and radiation from the searingly hot Trapezium stars erode the bubble, sweeping it into a teardrop. Magnetic fields from some of the young, central stars channel bipolar jets of material from the disks into space.

image of the region from Hubble, obtained by Kevin Luhman of the Harvard-Smithsonian Center for Astrophysics and his colleagues, reveals swarms of brown dwarfs, many of which had never been seen before. Some may be stranger objects yet — planetary-mass objects with masses as low as a few Jupiters that don't orbit host stars. How such free-floating "planemos" form is a topic of much current research. A finding, by myself and others, that they harbor dusty disks, like those seen around stars, suggests brown dwarfs and planemos form the same way stars do: by a gradual accumulation of gas. One theory proposes these objects are stellar embryos ejected from newborn multiple-star systems before they gather enough mass to fuse hydrogen.

To the northwest and southwest of the Trapezium are two clusters of heavily enshrouded protostars best seen in the infrared. The brighter of the two, to the northwest, contains a remarkable protostar called the Becklin-Neugebauer object, which shines with a luminosity of 10,000 Suns. Named after its discoverers, Eric Becklin of the University of California in Los Angeles and Gerald Neugebauer of the California Institute of Technology, the BN object illuminates an extended infrared nebula. Named Kleinmann-Low after Susan Kleinmann of the University of Massachusetts at Amherst and Frank Low of the University of Arizona who first imaged it, this nebula hosts powerful outflows and strong shocks that may be caused by the BN object or its luminous neighbors. Even after decades of intense multi-wavelength observations, the BN-KL region remains somewhat enigmatic.

The southwestern source, called Orion-S, is probably denser than the BN-KL region, so radiation from the neighboring Trapezium stars has penetrated it even less. Two bipolar outflows emanate from Orion-S, probably launched by deeply embedded protostars that remain invisible even in the near-infrared. Charles Lada at the Harvard-Smithsonian Center for Astrophysics and his colleagues have recently identified a candidate protostar for these outflows in Orion-S by observing in the mid-infrared.

It is hard to overstate how much our present understanding of star formation owes to studies of the Orion Nebula and its neighboring clouds. The nebula is often where a new phenomenon is uncovered or a new theory is put to the observational test. But this ethereal beauty has not revealed all its mysteries yet. Astronomers will be intrigued by the Orion Nebula for centuries to come. ◼

For a gallery of M42 images and a link to the Hayden Planetarium's 3-D fly-through of the nebula, visit www.astronomy.com/toc

# The outsider

David Helfand is an astronomer who doesn't like to look at the sky, a decorated department chair who refuses tenure, and a one-time theater major who wishes NASA would act with less drama. /// BY BOB BERMAN /// PHOTOS BY JEFF CHRISTENSEN

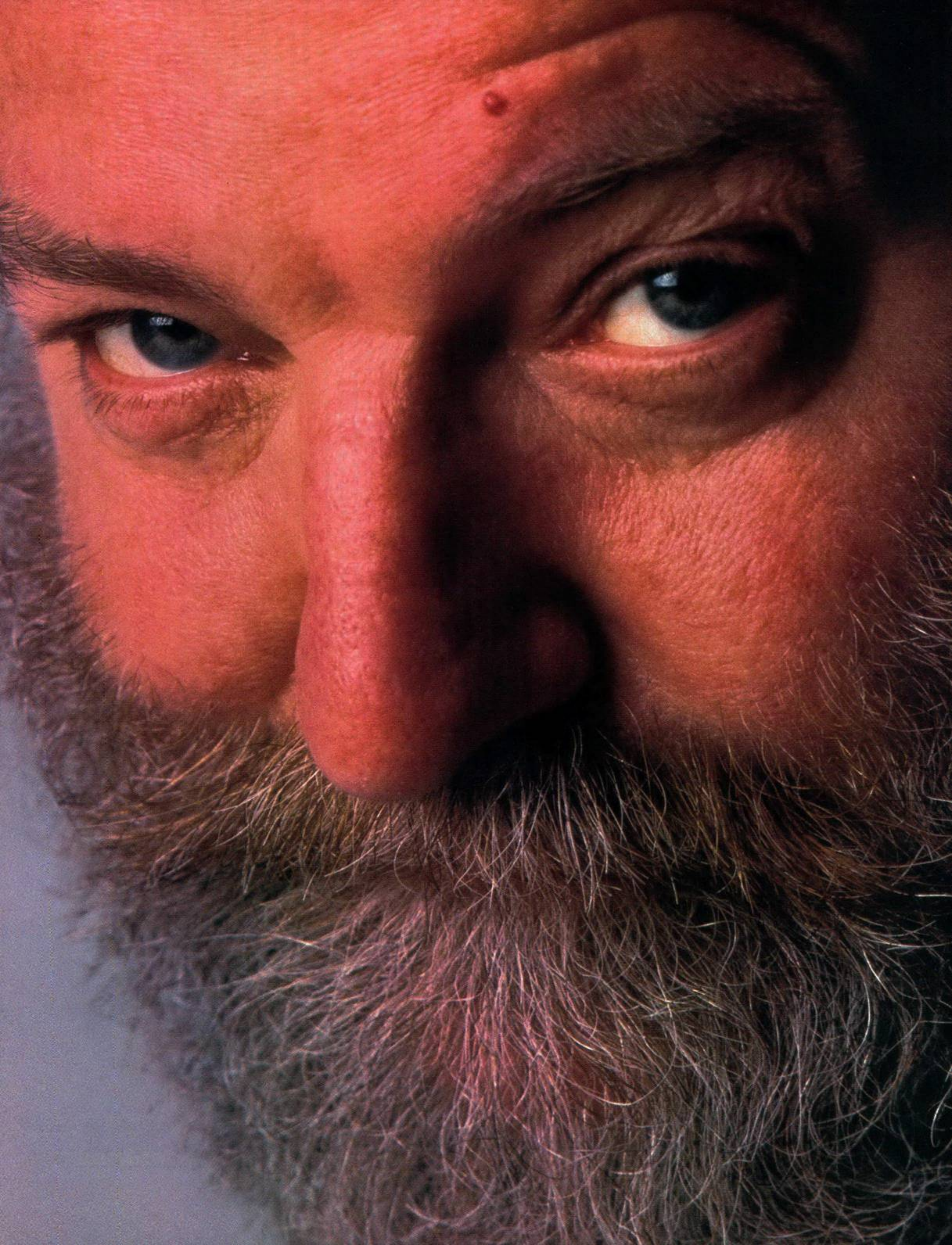
Toss out whatever you think you know about professional astronomers. Stodgy? Mainstream? Head in the clouds? No, no, and no — that's not David Helfand.

The moment you walk into his office a few floors below the observatory dome at Columbia University's Pupin Hall in the heart of New York City, you get a sense of displacement. The guy looks like a young Santa Claus with a gray beard and intense, twinkling eyes. But such first impressions are belied by a no-nonsense demeanor that has made him a pack of enemies. A celestial Santa — with enemies?

Heretics don't attract many friends, and Helfand's an especially vocal one. Although he took a traditional route to academia (graduating magna cum laude from Amherst College, earning a Ph.D. from the University of Massachusetts, and now serving as chairman of the astronomy department at Columbia), he strongly believes tenure is a bad thing. He refuses it and writes articles saying so. "It's a system that gives a person a lifetime of security without review," he asserts, "and that selects the wrong kind of people. It takes away the impetus for inspired teaching. It chooses and protects risk-averse people."

There aren't many Ivy League department chairs without tenure, but the insecurity doesn't bother Helfand a bit — although his beliefs irk plenty of professors elsewhere. His stance on transportation is equally polemical. He thinks cars are killing the planet; he doesn't own one or drive unless there's no alternative. When a visiting journalist asks about parking, he replies with barely concealed contempt.

The Santa Claus resemblance vanishes completely with the mention of how astronomy research is conducted, a subject about which he's



far from ho-ho-ho jolly. Although he's credited with important discoveries in a variety of areas (a process he describes as "setting mosaic tiles in place, one at a time"), his greatest influence is probably in the way astronomers work.

## Liberty and data for all

In the 1970s, Helfand explains, all NASA satellites were so-called PI-class missions (constructed by principal investigators), and the information they gathered became the exclusive property of the PI's team. Ground-based astronomy also had a long tradition of allowing astronomers to own the data they harvested, even if the information was collected at a federally supported facility. This greatly troubled the young Helfand, who saw it as "just another example of a competitive, rather than a cooperative, approach to science." So he pushed hard to create public archives where information was available to everyone.

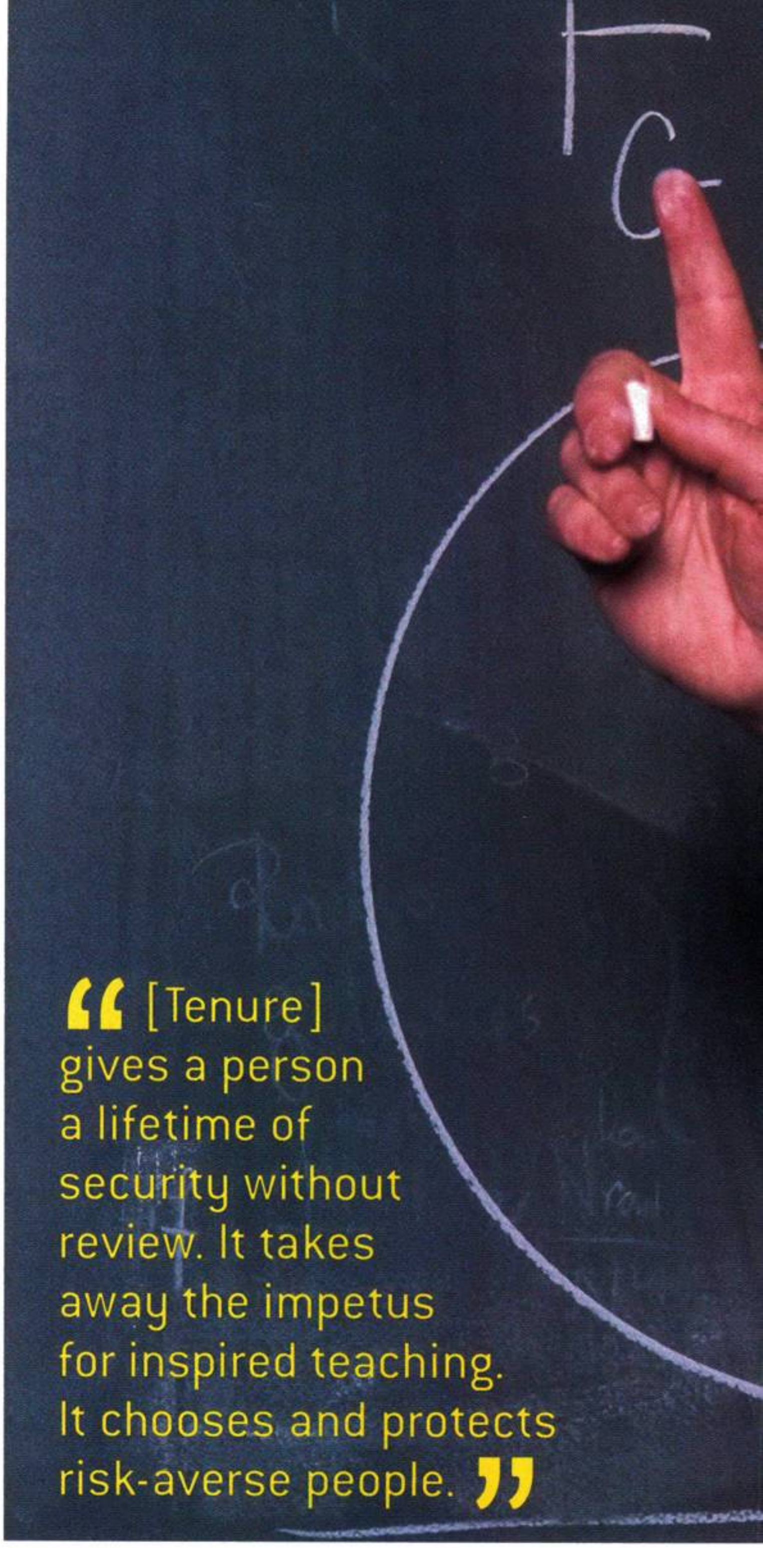
In 1990, Helfand and his collaborators Bob Becker from the University of California at Davis and Rick White from the Space Telescope Science Institute (STScI) proposed the then-novel idea of having the Very Large Array (VLA) in New Mexico commit to a multi-year project to precisely map the extragalactic sky. Before that, the instrument had focused only on individual objects of interest. Dedicating great amounts of time to a detailed survey for who-knows-what eventual knowledge was a hard sell, but Helfand made it happen. Started in 1993, the survey has provided the highest-ever resolution of the extragalactic sky in radio wavelengths. This success, in turn, convinced others that premier instruments could and should be used for large-scale surveys and other big projects. And, of course, Helfand and his team made the data, maps, and catalogs produced by this survey, called FIRST, publicly available, even on the Web. But Helfand won no popularity contests when he openly criticized other projects (like the German ROSAT X-ray mission launched in 1990) that did not similarly share their findings.

These days, unrestricted release of information is more the rule than the exception in science, although Helfand scolds the optical community for being "considerably slower to catch on." Still, more and more researchers share his view that "the best science is done when the maximum number of people have access to the data."

## The truth sometimes hurts

When it comes to scientific results, Helfand calls them like he sees them, regardless of how eminent the scientist responsible for them is. More than a decade ago, Riccardo Giacconi, one of the fathers of x-ray astronomy and co-winner of last year's Nobel Prize in physics, published an analysis of the deepest images taken by the Einstein Observatory, the first imaging x-ray telescope in space. The images seemed to show many faint x-ray sources, leading the research team to conclude that the number of x-ray emitters grew in direct proportion to the volume searched. But after analyzing the data himself, Helfand became convinced that many of the faintest sources were spurious signals from the detector.

"Liar!" Giacconi called out after Helfand presented this analysis at a conference in what was then Soviet Georgia. But in the end, Helfand proved to be right. The signals did not exist.



> “[Tenure] gives a person a lifetime of security without review. It takes away the impetus for inspired teaching. It chooses and protects risk-averse people.”

Sometimes the disputes Helfand finds himself in are more silly than scientific. Helfand's radio catalog was called FIRST (an acronym for Faint Images of the Radio Sky at Twenty-centimeters), but in keeping with the all-important objective of giving your project a catchy label, a European group wanted to use that name as well. Helfand's team got the moniker, he says, "when they first realized we had FIRST first."

Even NASA has been singed by Helfand's reproach. For the last fifteen years or so, Helfand has served on NASA advisory committees dealing with everything from space telescopes to digital libraries. "I naively thought I was actually supposed to give

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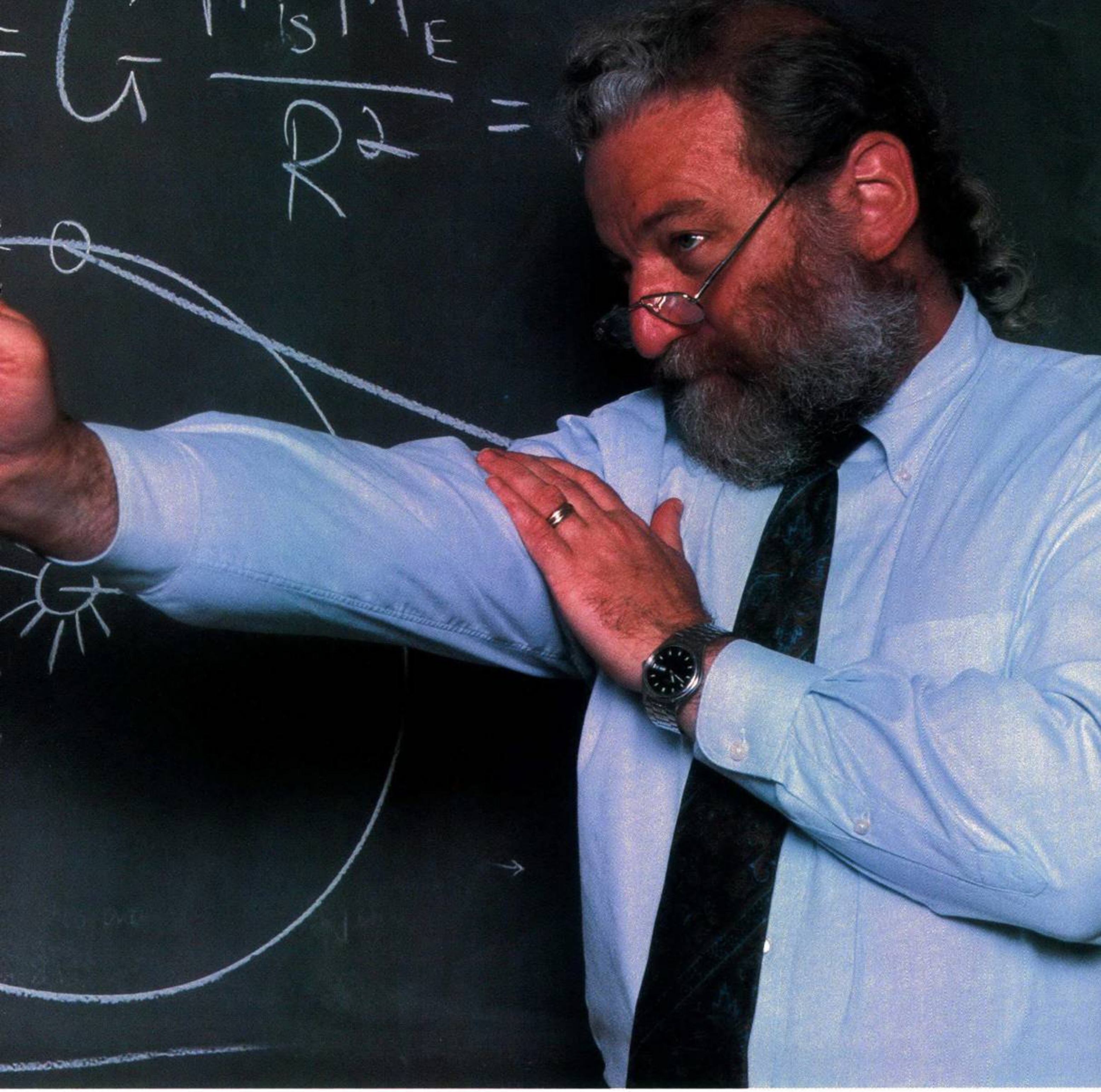
**Bob Berman** *teaches astronomy at Marymount Manhattan College. His book* Strange Universe *will be published this month by Times Books.*

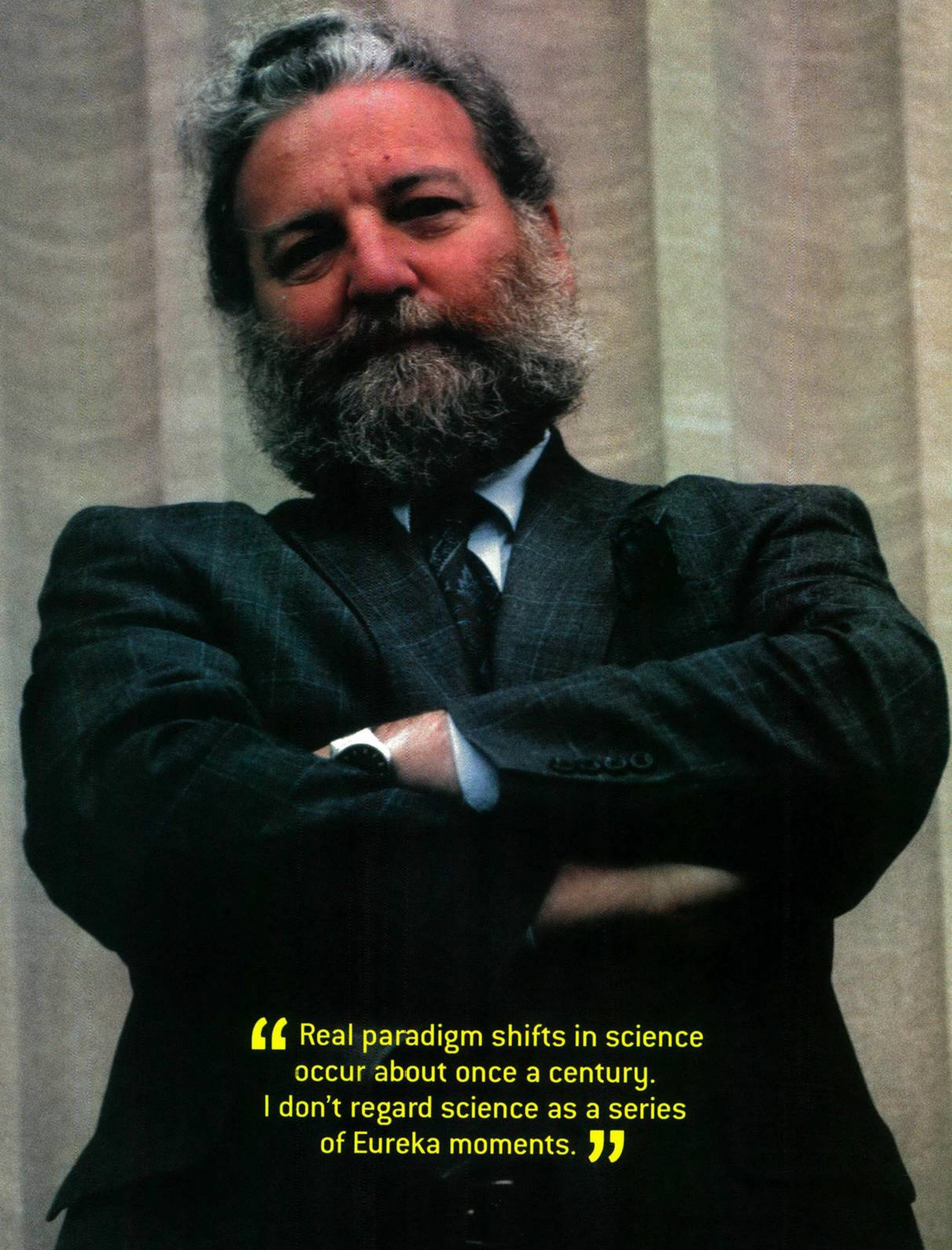


advice," he says. In his opinion, NASA is a politicized entity far less interested in optimum science than in immediate, headline-grabbing results. He tells of NASA employees and insiders given the green light for projects that advisory panels had deemed far inferior to competing submissions from outside universities.

But in spite of his outspoken criticism — or perhaps because of it — NASA has asked him back time and again. And his outsider perspective has even gained him admirers. "He's bright and iconoclastic, and we need that in science," says Guenter Riegler, director of astrobiology and space research at NASA's Ames Research Center. "It's always important to listen to him," he says, recalling an episode about fifteen years ago when Helfand proposed analyzing data from the Einstein Observatory x-ray mission in a new way. "His analysis was well received by the scientific community."

## Spin city

While erroneous results and bureaucracy irk Helfand, his biggest complaints are aimed at what he sees as NASA's obsession with "gaining column inches in *The New York Times*," especially with exotic-sounding phenomena. In April 2002, for example, NASA's "publicity machine" (as Helfand calls it) announced the discovery of a class of objects called quark stars that had been postulated



> “Real paradigm shifts in science occur about once a century. I don’t regard science as a series of Eureka moments.”

but never actually seen. Denser than neutron stars, these ultra-compact bodies were said to be packed with individual quarks (previously believed to occur only in threesomes) of the "strange" variety, making them the first objects found to consist of naked fundamental matter. But Helfand, an expert on neutron stars, joined other prominent astrophysicists who found the data unconvincing (see Helfand's article, "Way too cool," in *Astronomy*, March 2003). A few months later, almost no one in the astrophysics world believed an actual quark star had been found. While there may be a small percentage of free quarks in the cores of the two candidate objects, both are probably composed of mostly garden-variety neutrons. The news died quietly, but once again, NASA had landed big headlines.

Meanwhile, warns Helfand, "We are playing a very dangerous game. The basic nature of science is being distorted in the public mind." By releasing weekly press reports, he says, "NASA is making people forget that the essence of science lies in its slow, incremental accumulation of observations, experiments, and mathematical models. By creating the impression that NASA and its scientists are somehow producing epochal discoveries and titanic paradigm shifts every week, how can anyone be expected to take it seriously? Who are we kidding?"

He fears that science itself is harmed by the razzle-dazzle, headline-directed approach and that funding decisions and research agendas are increasingly driven by public relations departments. For example, a multi-year survey of what's out there (like the European Space Agency's Hipparcos satellite that precisely measured the distances to more than 100,000 stars between 1989 and 1993) produces few news stories. But the data are invaluable. Helfand's pet peeve is the tendency for funding agencies to overlook such important, basic work in favor of flashy, 15-minutes-of-fame enterprises.

"The worst thing I could accuse David of is being too idealistic," says Bruce Margon, associate director for science at STScI. Margon agrees that NASA doesn't publicize every research result. But he says, "That's no indictment. It just means that since the press and public aren't interested in detailed, technical-sounding research, NASA merely hands out what it knows will appeal to the mass media . . . There's no secret pact to push through what's sensational."

For its part, NASA says its Space Science Update press conferences are almost always based on peer-reviewed papers, whose authors comment on the results. "We help only to reduce the level of scientific jargon and to keep their presentation concise, interesting, and foremost in our minds, scientifically valid," writes NASA spokesperson Don Savage in an e-mail. Independent experts at the press conferences, he continues, "are especially encouraged to speak up if they disagree with the interpretations of the results."

## From stage to sky

This outer-space Don Quixote began his journey not as a backyard amateur, but as a theater major. He never owned a telescope, doesn't know his way around the night sky, and isn't interested in taking a look. He was bitten by the astronomy bug when he took an introductory class in the subject in college.

"I became truly engaged by the notion of eclipsing binary stars — by the fact that one could simply monitor the brightening and dimming of a single point of light . . . and from that, determine accurate stellar masses, diameters, temperatures . . . Overall, it was much more an intellectual captivation than a romantic one."

It still is. "I don't know any constellations," he confesses, "I'm more interested in how it works than where it is." Indeed, when Comet Shoemaker-Levy 9 collided with Jupiter a few years ago, an excited colleague phoned to invite Helfand to observe the dark debris zones through a major telescope. "Not interested," Helfand recalls saying, "I'm in the middle of dinner." (That may not have been as lame an excuse as it sounds. Helfand's a gourmet cook and works without recipes. Capers in the pot actually may have seemed more intriguing than the similar-looking dark blotches near the jovian equator.)

But Helfand is quite passionate about those subjects he finds intellectually stimulating, and despite his ambivalence about stargazing, most of his research has focused on cutting-edge observations. From the Very Large Array to the Chandra X-Ray Observatory, he has worked with some of the finest instruments around on topics from neutron stars to quasars. His enthusiasm shines through when he talks about supernovae, objects of particular fascination. "They're responsible for distributing all the elements lighter than iron to interstellar space and for creating all the heavier ones," he says, his eyes finally resembling Santa's as they sparkle with excitement. "They're the birthplaces of neutron stars and black holes, the source of cosmic rays, and the main source of energy input to the interstellar medium, thus shaping the structure of the whole galaxy."

## Slow and steady wins the race

What's next for the rabble-rousing astronomer? Already the author of 150 published articles, Helfand remains involved in projects as diverse as surveys with the VLA and changing the way science education functions in the United States.

Vehemently against standardized testing, he thinks failures in K–12 education pose the greatest problems for our country. Since coming to Columbia 26 years ago, he has spent much of his time on committees reworking the university's basic science courses. One of two professors to win last year's Great Teacher Award at Columbia, Helfand assigns projects such as estimating the number of piano tuners in New York City. The students "guesstimate" the percentage of households with pianos and how often each instrument requires tuning to infer how many people offer that service. Helfand believes this kind of basic logic, along with work that fills in scientific puzzles piece by piece, can be worth infinitely more to science education than dozens of splashy headlines announcing revolutionary breakthroughs. "Real paradigm shifts in science occur about once a century," he says. "I don't regard science as a series of Eureka moments."

Profiles usually highlight how a scientist has changed *what* we think. But David Helfand's distinctiveness lies in the way he wants to change *how* we think. Given his iconoclastic nature, it's tempting to dramatize his courageous and sometimes isolating crusades. But to do so would disrespect his very disdain for sensationalism. And how do we wave the flag of his individual discoveries when he insists on emphasizing the "brick by brick" accumulation of knowledge? No ground-breaking headlines for him.

In other words, he's not the kind of beloved and lauded personage a magazine would want to feature. Nope. Not at all. ■

To learn more about the controversial issue of college tenure, visit www.astronomy.com/toc

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Meade 8" LX200 GPS

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$1495

Meade 8" LX90

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Here are some of the TeleVue refractors we carry in stock for immediate shipment.

| | |
|---|---|
| **NP-101,** 4" f/5.4 apo | $\$3595^{00}$ |
| **TV-102,** 4" f/8.6 apo | $2635^{00}$ |
| **Renaissance 102,** 4" f/8.6 brass apo | $3175^{00}$ |
| **TV-85,** 3.35" f/7 apo | $2080^{00}$ |
| **TV-76,** 3" f/6.3 apo | $1675^{00}$ |
| **Pronto,** 2.7" f/6.8 semi-apo | $1120^{00}$ |
| **Ranger,** 2.7" f/6.8 semi-apo | $760^{00}$ |

All of the above scopes come without a mount, but with an eyepiece (except NP-101), enhanced aluminum or Everbrite star diagonal, tube ring for mounting, and case. Basic optical tubes, without accessories, are also available.

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TMB 105

A *Sky & Telescope* review said the **TMB** triplet apochromatic refractor had "optics as good as I have seen in any refractor, indeed in any telescope I've tested or used at any price." That's high praise from an unbiased reviewer.

The TMB ED apo refractors have optically exceptional air-spaced triplet optics and high precision mechanics (such as a 3" focuser).

You can have an absolutely premium TMB triplet apo optical tube a lot sooner than you might think. For details and pictures, visit our website to see the TMB apo refractors that are the talk of experienced astronomers everywhere. Here's a list of the sizes available.

| | |
|---|---|
| **TMB 80** 80mm (3.1") f/6 or f/7 | $\$1990^{00}$ |
| **TMB 105** 105mm (4.1") f/6.2 | $3590^{00}$ |
| **TMB 115** 115mm (45") f/7 | $4390^{00}$ |
| **TMB 130** 130mm (5.1") f/6 | $5390^{00}$ |
| **TMB 152** 152mm (6") f/7.9 | $7590^{00}$ |
| **TMB 175** 175mm (7") f/8 | $12{,}990^{00}$ |
| **TMB 203** 203mm (8") f/9 | $24{,}990^{00}$ |
| **TMB 229** 229mm (9") f/8.95 | $24{,}990^{00}$ |
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The information is yours for only the time it takes to make a free phone call. The information and pricing we send will make it the most useful minute you'll ever invest in astronomy.

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8" f/6 DHQ

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Why settle for an imported Dobsonian reflector with so-so optics when you can have genuine made-in-the-USA quality for the same money? Discovery optics are made in California by experienced optical craftsmen, one quality mirror at a time. The 6" to 13.1" Discovery DHQ Dobsonians have an adjustable metal mirror cell, a true *thin vane* adjustable 4-vane diagonal mirror spider, *two* 1.25" Plössl eyepieces, a 2" metal rack and pinion focuser with a 1.25" eyepiece adapter, a unique built-in tube balancing system, a tube carry handle, new oversized bearings, a 6 x 30mm finderscope, and a tube end dust cover. For only $49 more, you can get an upgrade package that gives you two more Plössl eyepieces, an eyepiece rack for the side of the scope, a second dust cover, and a Moon filter!

Here are the prices for the fully-equipped Discovery DHQ Dobsonians. Freight from the factory in California is additional, as shown.

| | | |
|---|---|---|
| 6" f/5 Discovery DHQ | $\$339^{00}$ | + $49 freight |
| 6" f/8 Discovery DHQ | $339^{00}$ | + $49 freight |
| 8" f/6 Discovery DHQ | $449^{00}$ | + $49 freight |
| 8" f/7 Discovery DHQ | $449^{00}$ | + $49 freight |
| 10" f/4.5 Discovery DHQ | $649^{00}$ | + $69 freight |
| 10" f/5.6 Discovery DHQ | $649^{00}$ | + $69 freight |
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FSQ-106N, **$3475.** EM-2S mount, **$2229.**

While many people swear *at* the one to three year delivery schedule quoted by some premium refractor makers, most experienced astronomers swear *by* the unsurpassed optics and fast delivery of the Takahashi *apochromatic* refractors we keep in stock.

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AT1010N **$499**
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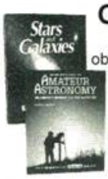

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CELESTRON

NexStar 5i
**$999**

the Nexstar 5i is shown with optional photography accessories

NexStar 8i
**$1299**

When you compare 5" and 8" go-to telescope prices, the **Celestron NexStar 5i** and **NexStar 8i** stand out as bargains.

The **NexStar 5i** is a complete go-to telescope ***for only $999!*** The NexStar 5i comes with a tripod, 5" f/10 Starbright multicoated optics, an *iCOMP* computer hand control with a 40,000 deep space object memory, finderscope, eyepiece, and more. An optional $199 GPS module is available for fully automatic alignment on the sky. No other 5" scope even has GPS – and even without GPS the NexStar 5i costs less than other multicoated 5" scopes.

Starbright multicoated optics are standard equipment with the Celestron NexStar 5i. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality?

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**$2999**

NexStar 11 GPS

Celestron's 11" fork-mounted go-to **NexStar 11 GPS** got a *rave* review in *Sky & Telescope*. The review gave the telescope "an enthusiastic two thumbs up and a gold star."

The magazine said the scope has "brains and good looks. The NexStar 11 GPS puts Celestron's time-tested 11-inch f/10 Schmidt-Cassegrain optics in a sleek new package that includes some of the most advanced electronics ever offered in a mass-produced telescope . . . Celestron is the first to take Go To scopes to the next step in their evolution, and it's a nice step indeed."

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**$4295**

Meade 14" LX200 GPS

Even though we averaged selling over four 12" LX200s every week the past year, it is still only number four on our list of Meade go-to best sellers! Three other 8" and larger Meade go-to scopes outsold it. Will the new $4295 14" LX200 GPS also outsell the $3295 12" scope? We'll just have to wait and see. If it does, it will be because it was the right telescope for those who bought one.

That's why we sell the most Meade scopes – because we care enough to make sure the scope you buy is the one that's right for you. Not the one we have too many of . . . not the one with the biggest profit . . . but the one that fits *your* needs, *your* abilities, *your* observing site, *your* budget. It's that kind of caring service that keeps people coming back to us again and again.

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Vixen

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BY MARTIN RATCLIFFE AND ALISTER LING

## OCTOBER 03

Brilliant Mars remains the showcase of the evening sky, while Mercury puts on a fine display in the hour before dawn.

# Mars commands the southern sky

Despite what you might think, it's way too early to say goodbye to Mars. In early October, more than a month after its closest approach to Earth, the Red Planet looms larger than it will at any time before 2018. You can find Mars shining brightly in the south all evening long. Although Mars has already started to shrink, its topography and meteorology should remain at the top of your observing ticket. Once December arrives, its smaller size, combined with Earth's more turbulent atmosphere, will challenge Mars fans who hang on until the end.

While twilight quickly swallows more distant outer planets like Jupiter and Saturn, Mars takes months to disappear. It will remain visible until next summer. Because its smaller orbit forces it to move much faster than the gas giants, Mars comes closer to matching Earth's orbital speed. By next March, it will cruise past the Pleiades, the lovely star cluster just now climbing in the east during late evening. That's a lot of sky to cross.

Venus emerges slowly into the evening sky late this month. Despite its phenomenal candlepower, the "evening star" stays pretty well hidden in the bright twilight. To spot it, scan the west-southwestern horizon with binoculars 30 minutes after sunset. As Venus ascends to her throne in the coming months, she will take part in a series of wonderful conjunctions with the Moon.

**MARS REMAINS A STUNNING SIGHT** throughout October, although slightly less spectacular than at its peak in August. STEVE LEE (UNIVERSITY OF COLORADO), JIM BELL (CORNELL UNIVERSITY), MIKE WOLFF (SPACE SCIENCE INSTITUTE), AND NASA

Uranus and Neptune remain well placed in the early evening sky, floating in the distance beyond Mars. A small backyard telescope will bring both into view. For finder charts, see "Gunning for the gas giants" in the July 2003 issue or visit Astronomy.com.

Mercury begins October in the midst of its best morning apparition of 2003, but make haste. The fleet-footed messenger of the gods sinks quickly into the Sun's glow during the second week of the month. At magnitude –0.8 on October 1, Mercury stands out as a yellow dot against the orange twilight.

This month's Full Moon, also known as the "Hunter's Moon," falls on the night of October 9/10. As it circles the sky, the Moon appears about half-lit by the 17th when it passes Saturn, and it develops into a nice crescent by the 21st when it passes Jupiter.

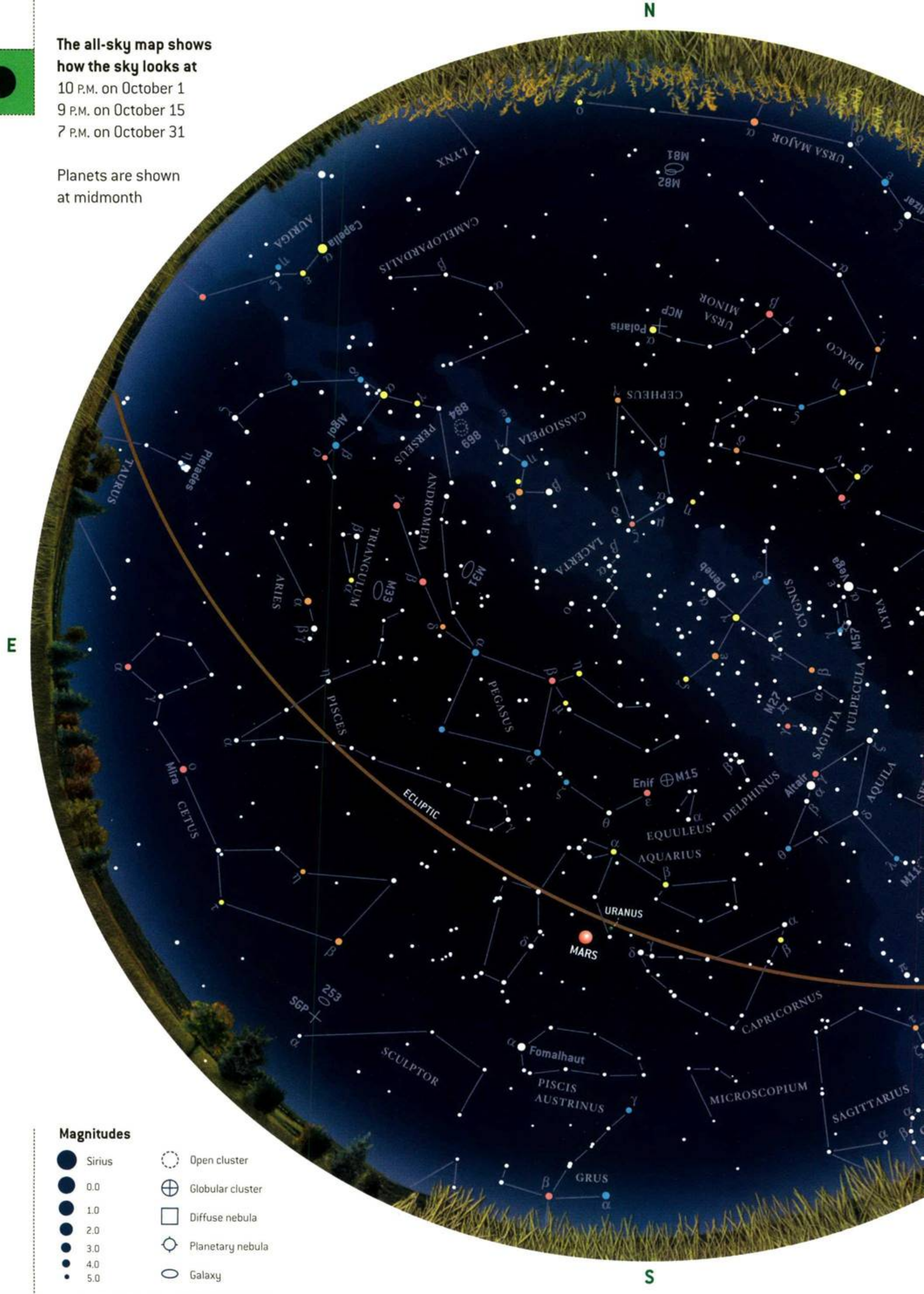
Meteor fans should plan to be outside on Tuesday night, October 21/22, the peak of the annual Orionid shower. Early morning observers should see a dozen or so "shooting stars" per hour, with fewer numbers visible a night or two before and after. Orionid meteors derive from tiny dust particles left behind by Comet Halley that hit and then burn up in Earth's atmosphere.

Speaking of comets, we're crossing the threshold of an extended season of fine apparitions. Between now and late next spring, we will be treated to a nice view of Comet Encke, followed by two other "fuzzy snowballs" that should be visible to the naked eye. You already may know that nice comets often arrive with little advance notice. Could we be so lucky as to get another?

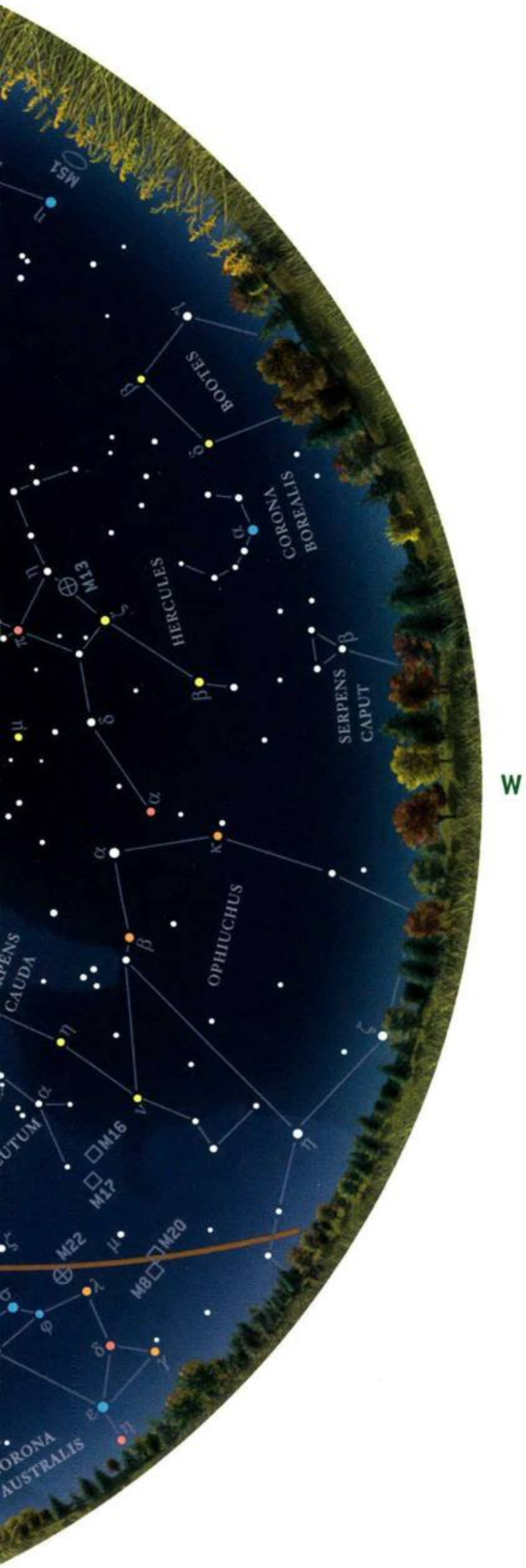
Binoculars should be a basic tool in everyone's observing kit. Not only are they extremely portable and perfect for tracking approaching comets, they also can outperform telescopes on some deep-sky objects. The magnificent Pinwheel Galaxy (M33) is a snap to find with binoculars under a dark sky. A modest-sized telescope in the city usually fails the Pinwheel challenge, but it excels in following asteroids and splitting tight double stars.

**The all-sky map shows how the sky looks at**
10 P.M. on October 1
9 P.M. on October 15
7 P.M. on October 31

Planets are shown at midmonth

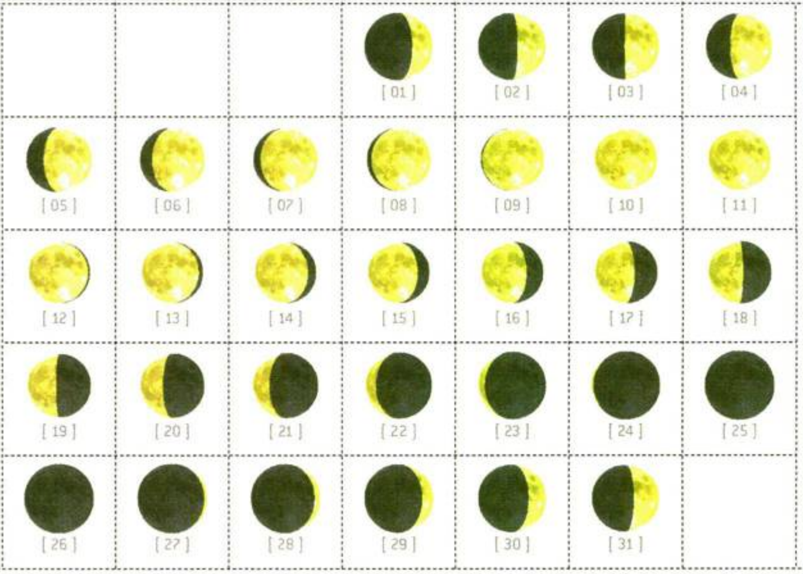

N
LYNX
URSA MAJOR
M81
M82
AURIGA
Capella
CAMELOPARDALIS
URSA MINOR
NCP
Polaris
DRACO
CEPHEUS
CASSIOPEIA
884
869
PERSEUS
Algol
Pleiades
TAURUS
ANDROMEDA
TRIANGULUM
M33
M31
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
ARIES
E
PEGASUS
PISCES
M27
SAGITTA
VULPECULA
Mira
CETUS
ECLIPTIC
Enif
M15
DELPHINUS
Altair
AQUILA
EQUULEUS
AQUARIUS
URANUS
MARS
CAPRICORNUS
SGP
253
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
SAGITTARIUS
GRUS
S
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions:
horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sk


M51
BOOTES
CORONA BOREALIS
HERCULES
M13
SERPENS CAPUT
OPHIUCHUS
PENS CAUDA
UTUM
M16
M17
M22
M8
M20
ORONA AUSTRALIS
W

orth, south, east, and west. To find stars above your
.

# october 03



| SUN. | MON. | TUES. | WED. | THURS. | FRI. | SAT. |
|---|---|---|---|---|---|---|
| | | | [01] | [02] | [03] | [04] |
| [05] | [06] | [07] | [08] | [09] | [10] | [11] |
| [12] | [13] | [14] | [15] | [16] | [17] | [18] |
| [19] | [20] | [21] | [22] | [23] | [24] | [25] |
| [26] | [27] | [28] | [29] | [30] | [31] | |

**02** First Quarter Moon is at 3:09 P.M. EDT

**03** Venus passes 3° north of Spica, 6 P.M. EDT

**04** The Moon passes 5° south of Neptune, 8 P.M. EDT

**06** The Moon passes 5° south of Uranus, 6 A.M. EDT

The Moon passes 1.1° south of Mars, 11 A.M. EDT

**10** Full Moon is at 3:27 A.M. EDT

**13** Asteroid Pallas is at opposition, 11 A.M. EDT

The Moon is at apogee (252,085 miles from Earth), 10:25 P.M. EDT

**17** The Moon passes 5° north of Saturn, 9 A.M. EDT

**18** Last Quarter Moon is at 8:31 A.M. EDT

**21** The Moon passes 4° north of Jupiter, 7 P.M. EDT

**22** Orionid meteor shower peaks

**25** Mercury is in superior conjunction, 6 A.M. EDT

New Moon is at 8:50 A.M. EDT

Saturn is stationary, 8 P.M. EDT

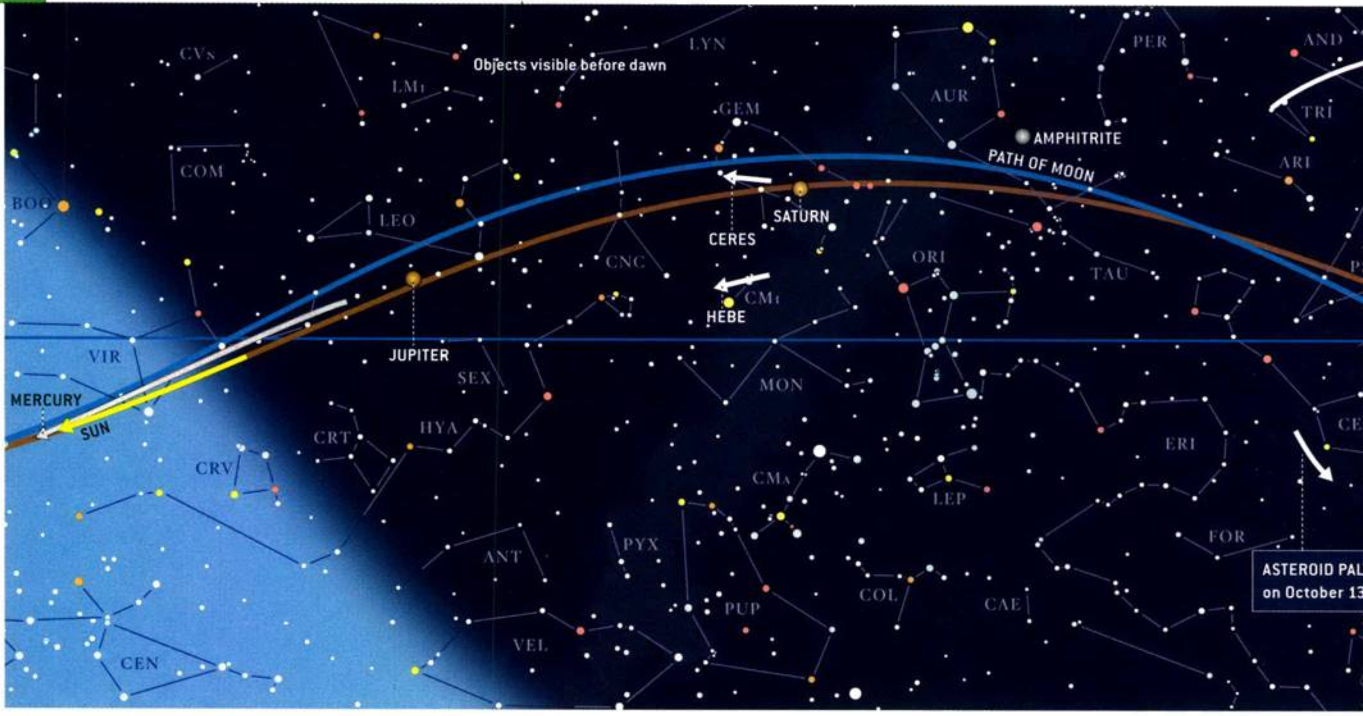
**26** The Moon is at perigee (222,791 miles from Earth), 6:30 A.M. EST

The Moon passes 0.08° south of Venus, 3 P.M. EST

**31** First Quarter Moon is at 11:25 P.M. EST

# Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and sc


Objects visible before dawn
CVn
LMi
LYN
GEM
AUR
PER
AND
TRI
ARI
AMPHITRITE
PATH OF MOON
COM
BOO
LEO
SATURN
CERES
CNC
ORI
TAU
HEBE
CMi
VIR
JUPITER
SEX
MON
MERCURY
SUN
CRT
HYA
ERI
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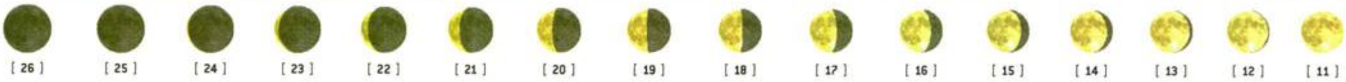
PYX
ASTEROID PAL
on October 13
PUP
COL
CAE
VEL
CEN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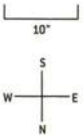
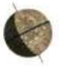
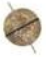
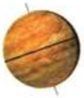
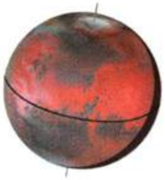
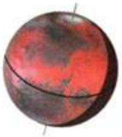
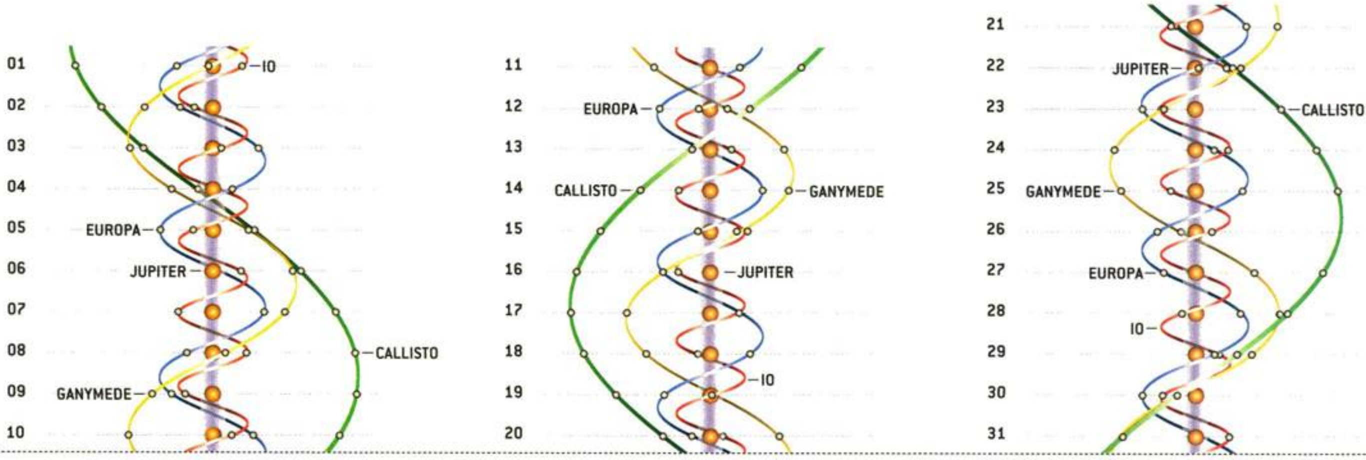
To locate the Moon in the sky, draw a line from the phase s



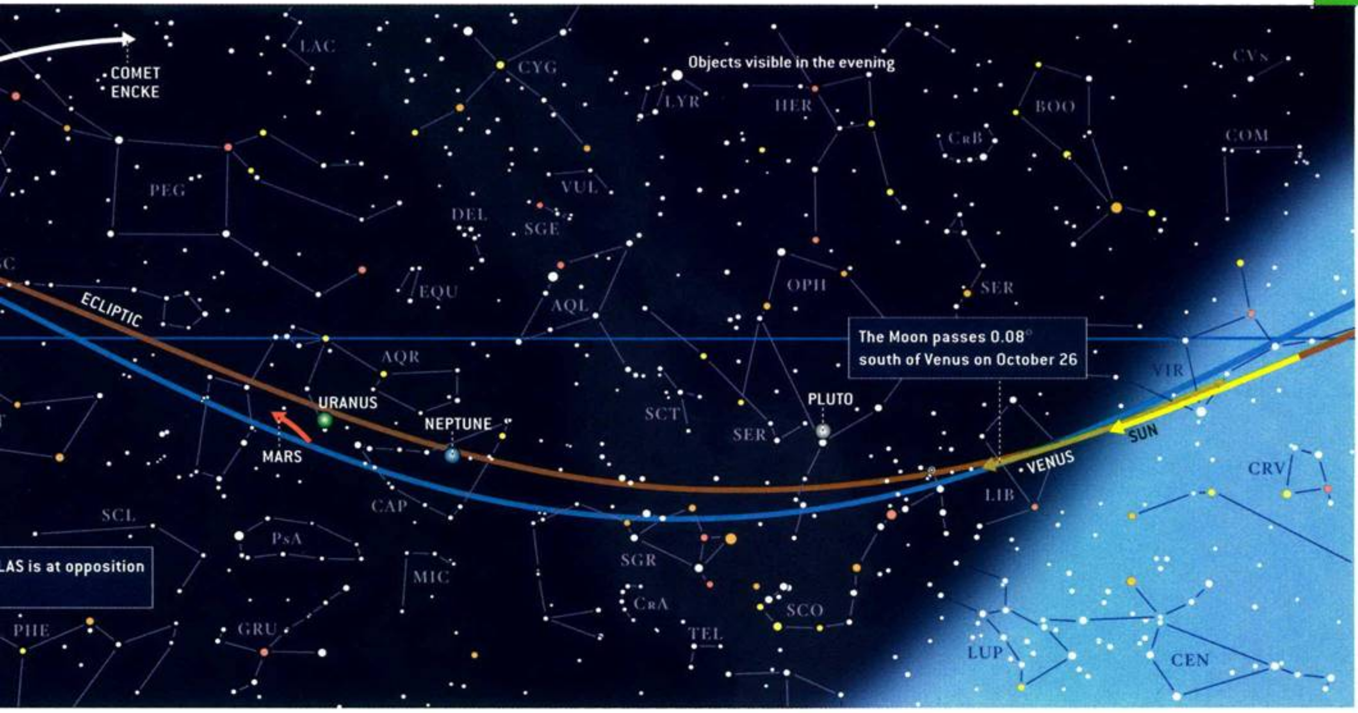
| PLANETS |  MERCURY |  MERCURY |  VENUS |  MARS |  MARS |
|---|---|---|---|---|---|
| Date | October 1 | October 15 | October 15 | October 1 | October |
| Magnitude | –0.8 | –1.2 | –3.9 | –2.1 | –1.2 |
| Angular Size | 6.3" | 5.0" | 10.2" | 20.7" | 15.1" |
| Illumination | 67% | 97% | 97% | 95% | 90% |
| Distance (AU) from Earth | 1.065 | 1.344 | 1.637 | 0.453 | 0.620 |
| Distance (AU) from Sun | 0.312 | 0.379 | 0.725 | 1.388 | 1.407 |
| Right Ascension (2000.0) | 11h27.4m | 12h53.1m | 14h17.1m | 22h15.6m | 22h38.1 |
| Declination (2000.0) | 5°17' | –3°56' | –13°12" | –15°41' | –11°13' |

# Jupiter's moons

Dots display positions of Galilean satellites at 5 A.M. EDT on date shown. South is at top to match the view in a telescope.

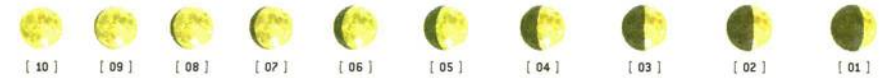


uares show motions and locations of solar system objects during the month.


COMET ENCKE
LAC
CYG
Objects visible in the evening
CVn
LYR
HER
BOO
CrB
COM
PEG
VUL
DEL
SGE
C
ECLIPTIC
EQU
AQL
OPH
SER
AQR
VIR
URANUS
NEPTUNE
SCT
PLUTO
SUN
MARS
SER
VENUS
CRV
LIB
CAP
SCL
PsA
SGR
MIC
CrA
SCO
TEL
PHE
GRU
LUP
CEN

The Moon passes 0.08° south of Venus on October 26

LAS is at opposition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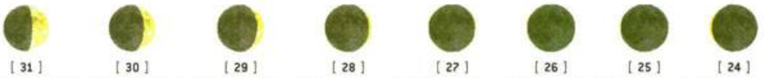
hown for the day straight up to the curved light-blue line.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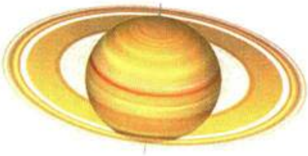
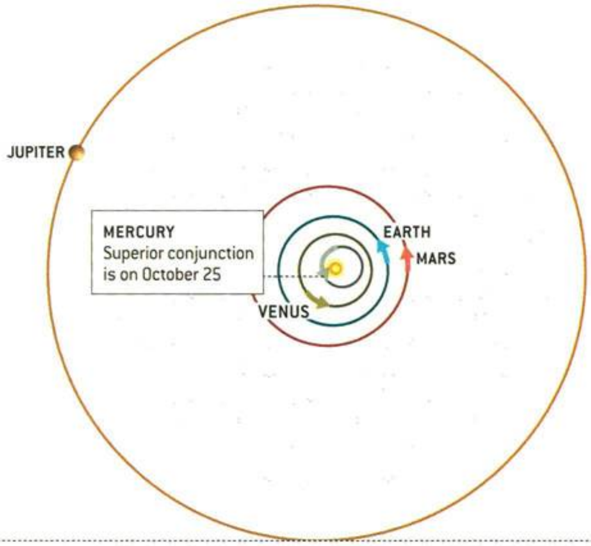


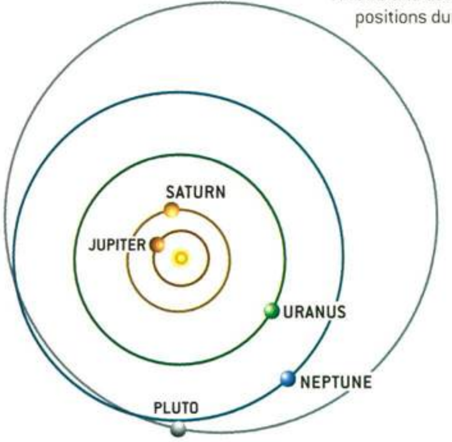
| | JUPITER | SATURN | URANUS | NEPTUNE | PLUTO |
|---|---|---|---|---|---|
| 1 | October 15 | October 15 | October 15 | October 15 | October 15 |
| | −1.8 | 0.0 | 5.8 | 7.9 | 13.9 |
| | 32.3" | 18.8" | 3.6" | 2.3" | 0.1" |
| | 100% | 100% | 100% | 100% | 100% |
| | 6.097 | 8.837 | 19.405 | 29.734 | 31.239 |
| | 5.386 | 9.032 | 20.033 | 30.077 | 30.707 |
| m | 10h47.7m | 6h56.5m | 22h06.0m | 20h51.3m | 17h10.2m |
| | 8°39' | 22°04' | −12°31' | −17°39' | −14°03' |

## The planets in their orbits

Arrows and dots show planets' positions during the month.


JUPITER
EARTH
MARS
VENUS

MERCURY
Superior conjunction
is on October 25


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

# THE DEEP SKY

Although it often comes as a surprise to novices, binoculars sometimes can provide an equal or better view than a telescope.

**THE SPIRAL GALAXY M33** in Triangulum ranks as one of the premier targets of the autumn sky. GEORGE GREANEY AND MIKE NEWTON

## Autumn twins

To a beginner, Aries and Triangulum form a conspicuous parallelogram of four stars. This can be confusing because the parallelogram spans two constellations, not one. At the bottom right of this grouping, a mere appendage to the naked eye, lies perfection. Gamma ($\gamma$) Arietis appears as a single star shining at magnitude 3.9, but a scope reveals two nearly identical white stars. Located some 200 light-years away and separated by 8", the two split comfortably when viewed at powers greater than 100x.

Next, slide 10° west into Pisces to the chain of stars consisting of Psi$^1$ ($\psi^1$), Psi$^2$ ($\psi^2$), and Psi$^3$ ($\psi^3$). A delightful double, Psi$^1$ features an easy 30" gap between its nearly equal magnitude 5.3 and 5.6 stars. If you can tell which one is brighter, you'd make a good variable star observer; they routinely need to estimate brightness differences that close or a bit finer.

Another identical pair lies northwest of the chain. Two magnitude 6.3 stars separated by 4.4" constitute 65 Piscium.

If that one still proves too easy, crank up the power on 36 Andromedae, located about halfway between 65 and Psi$^1$ Piscium. A gap of only 1.0" divides this slightly unequal pair of pale yellow, magnitude 6.0 and 6.4 stars. You'll need a steady night and a top-end 4-inch scope to split this pair. Try magnifications above 200x.

## Easy to be hard

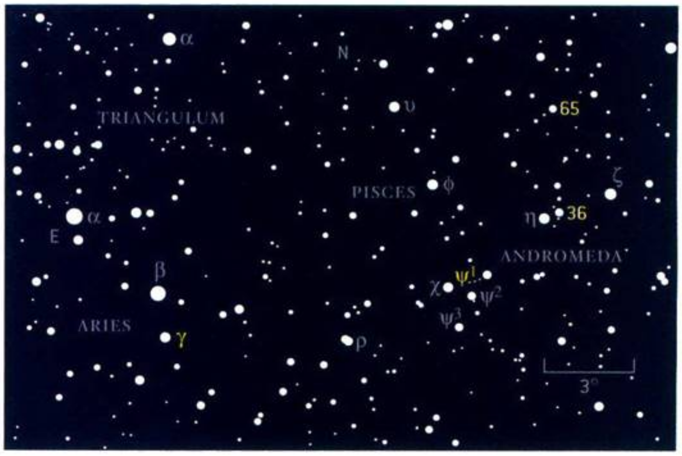
Without doubt, the Pinwheel Galaxy (M33) in Triangulum stands as one of the most beautiful galaxies in the sky. This graceful, three-arm spiral is chock full of clusters and gaseous clumps that can be seen in a large telescope from a dark-sky site. Under desert, prairie, or mountain skies, you can spy M33 even with dark-adapted, unaided eyes.

Sound easy? Low surface brightness makes it the bane of the neophyte galaxy hunter. Although it ranks among the brighter Messier objects, M33's light spreads out over such a large area that it almost disappears in the skyglow. It does vanish from the light-polluted sky of a backyard in the city.

The colorful clumps embedded in the Pinwheel's arms consist of ionized hydrogen, just like the Milky Way's Orion and Eta Carinae nebulae. One of M33's stellar nurseries, cataloged as NGC 604, glows so brightly you can glimpse it even when the rest of the galaxy is invisible. Look for a pair of stars just to the north of where you expect the galaxy to be located; one of the pair will look slightly fuzzy, that's the giveaway.

Should you get the chance to peek through a large scope at a star party, request M33. The subtle spiral arms peppered with knots as well as foreground stars glow against a soft background. Take the time to scan slowly across the galaxy's huge face.

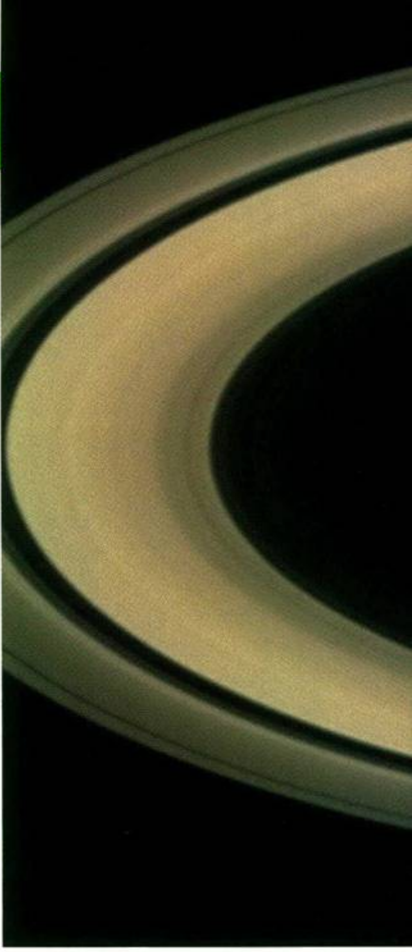
To avoid the negative effects of moonlight, wait until late October before heading out to the country. If you point your binoculars at the right spot, M33 will come through easily because a magnification of 7x or so concentrates its light into a fairly small zone. Unless you have a really dark site, you probably won't see it with the naked eye. Wait until a good rain has washed the dust and pollution out of the air. Now you can understand why no one spotted the Pinwheel until Messier did in 1764. At that time, most observatories were in cities and had to battle sooty air from burning coal.



**Martin Ratcliffe** *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist with Environment Canada.*

# THE PLANETS

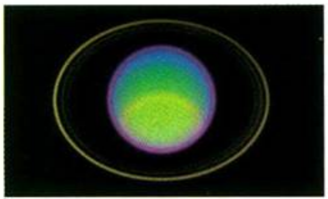
Venus joins Mars, Uranus, and Neptune in the evening sky, while Jupiter, Saturn, and Mercury put on a good show before dawn.



Mars continues its grand performance in early October, but its brilliance will be short-lived. As Earth moves rapidly away from Mars, observers will notice the planet's apparent size shrink significantly by month's end. The planet Uranus, located near Mars in the sky, can be seen easily in binoculars. The more challenging Neptune lies west of these two, completing a trio of planetary targets visible until past midnight. Venus returns to the evening sky, but it takes the stage somewhat tentatively. Views of it will improve later in the year. Meanwhile, Mercury, Jupiter, and Saturn adorn the morning sky.

As soon as the Sun sets in the first week of October, few people will miss the dazzling point of light called **Mars.** It lies high in the southeast as soon as darkness falls — shining brighter than any other point of light in the sky. It doesn't set until after 3 A.M. local daylight time. Don't miss the best views of Mars in the first two weeks of October, before the show noticeably starts to wind down. You'll find Mars 5° east of the gibbous Moon on the 5th.

As October opens, Mars has just concluded its retrograde loop and has begun moving eastward again against the background stars of the watery constellation Aquarius. Far to the south of Mars lies the 1st-magnitude star Fomalhaut in Piscis Austrinus.



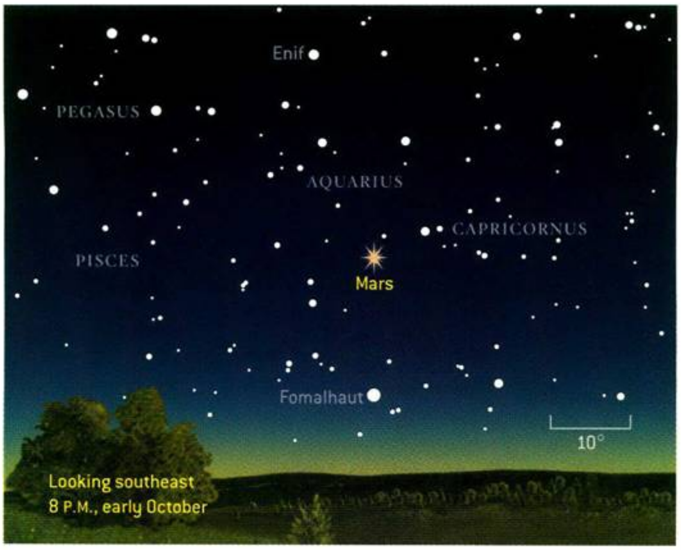
**GET A LOOK AT URANUS** while it stands high in the evening sky, but don't expect to see the detail Hubble can. ERICH KARKOSCHKA [UNIVERSITY OF ARIZONA LUNAR & PLANETARY LAB] AND NASA

Mars should provide superb views in any telescope. During the first two weeks of October, it still exceeds the apparent diameter it attains at most oppositions. As it has throughout this apparition, Mars reserves its subtle detail for observers who patiently wait for precious moments of good seeing, when atmospheric turbulence dies down and the image becomes rock steady.

Mars spans 21" in the eyepiece when October begins but shrinks to 15" thirty days later. Its brightness also fades this month, diving by more than a factor of two from magnitude –2.1 to –1.2. At month's end, notice that Mars shows a distinctly gibbous phase, being only 90 percent illuminated as seen from Earth.

The southern hemisphere of Mars experienced its summer solstice in late September, so its south pole now tips toward the Sun. Because Mars also lies near perihelion, the closest point to the Sun in its orbit, relatively intense solar heating is causing the south polar cap to shrink rapidly. The visibility of other surface features partially depends on whether dust storms have stirred up enough obscuring material to turn the planet into a bland, orange disk. If the atmosphere remains clear, you should see lots of dark features.

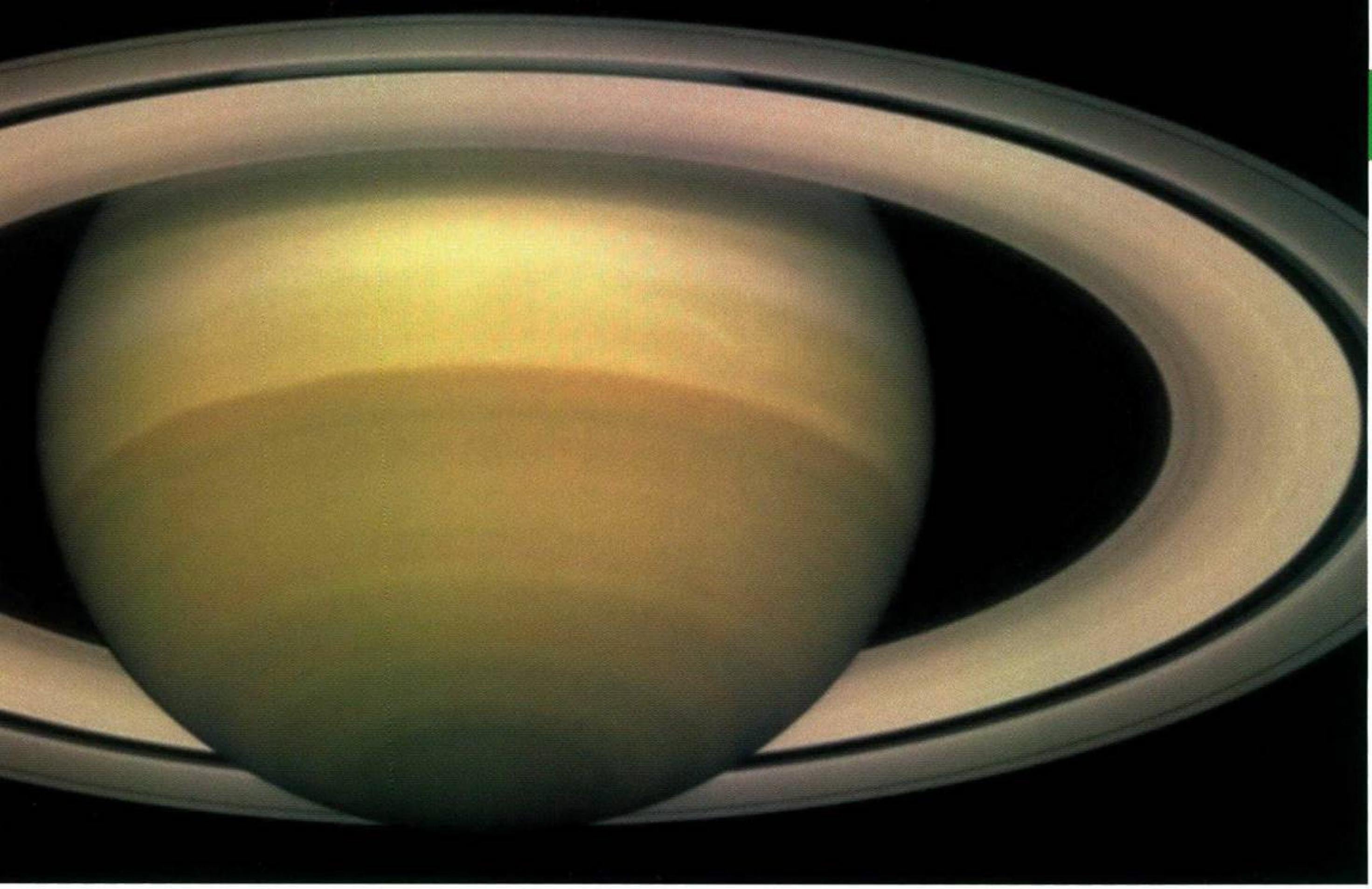
Although **Uranus** appears near Mars in the sky, in reality it lies much farther away. Shining at magnitude 5.8, Uranus shows up easily in binoculars. It lies in the same field of view as Mars in 7x50 binoculars, just north of the 4.3-magnitude star Iota (ι) Aquarii. A small telescope shows Uranus's pale blue-green color, while larger scopes reveal its 3.6"-diameter disk, which conveys its planetary status.



Looking southeast
8 P.M., early October

Farther west, among the dim stars of Capricornus, **Neptune** continues its wandering. Binoculars will show this faint planet too, but you'll need a telescope to clearly identify it. Neptune glows at magnitude 7.9 and lies in the same binocular field as 19 Capricorni, a 5.8-magnitude star 3° west of 4th-magnitude Theta (θ) Capricorni.

**Venus** makes a brief appearance just after sunset in late October. It remains low, hugging the west-southwestern horizon. Although it dips

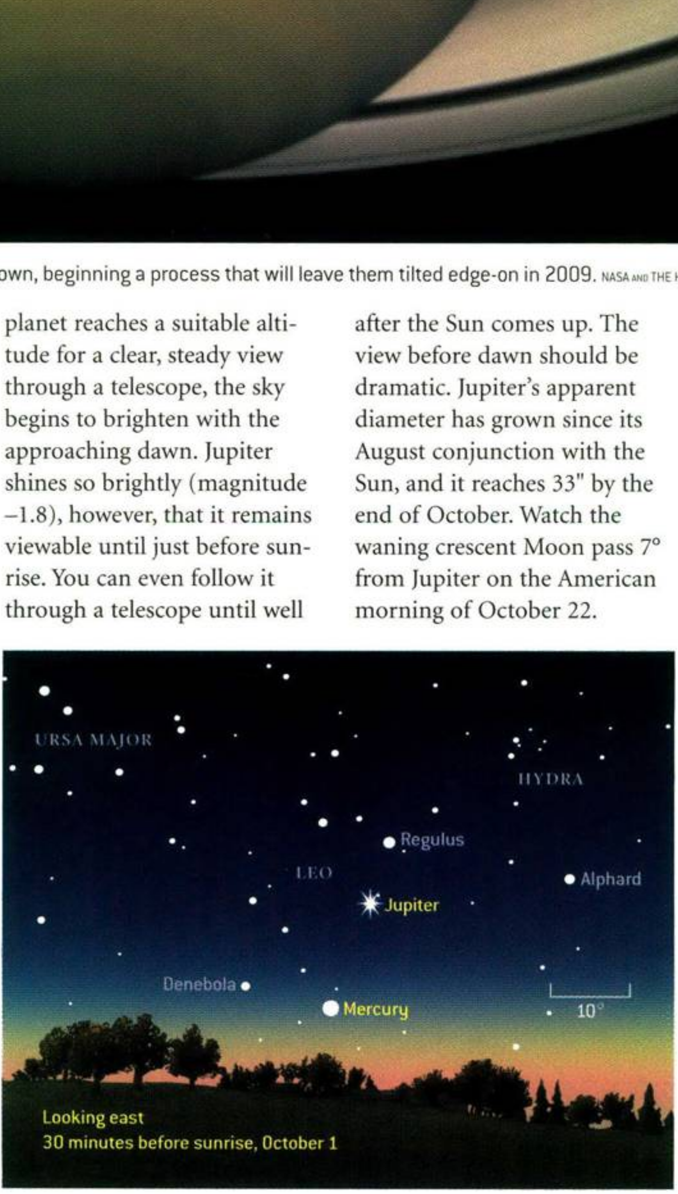


**SATURN'S RINGS** have started to close down, beginning a process that will leave them tilted edge-on in 2009. NASA AND THE HUBBLE HERITAGE TEAM (STScI/AURA)

below the horizon less than an hour after the Sun does, its brilliance, at magnitude –3.9, renders it visible even in fairly bright twilight.

During the early morning hours, as Mars drops in the southwest, **Saturn** rises in the east. The two combine to offer an entire night's worth of planetary viewing. On October 1, Saturn rises about midnight local daylight time along with Castor and Pollux, the two brightest stars in Gemini. Glowing brightly at magnitude 0.0, the planet easily outshines both neighboring stars. If you look carefully, you may notice the rings have closed a little since Saturn left the evening sky this past spring.

Saturn and the winter constellations of Taurus, Orion, and Canis Major stand high in the sky by the time **Jupiter** rises around 4 A.M. local daylight time. Just as the giant planet reaches a suitable altitude for a clear, steady view through a telescope, the sky begins to brighten with the approaching dawn. Jupiter shines so brightly (magnitude –1.8), however, that it remains viewable until just before sunrise. You can even follow it through a telescope until well after the Sun comes up. The view before dawn should be dramatic. Jupiter's apparent diameter has grown since its August conjunction with the Sun, and it reaches 33" by the end of October. Watch the waning crescent Moon pass 7° from Jupiter on the American morning of October 22.



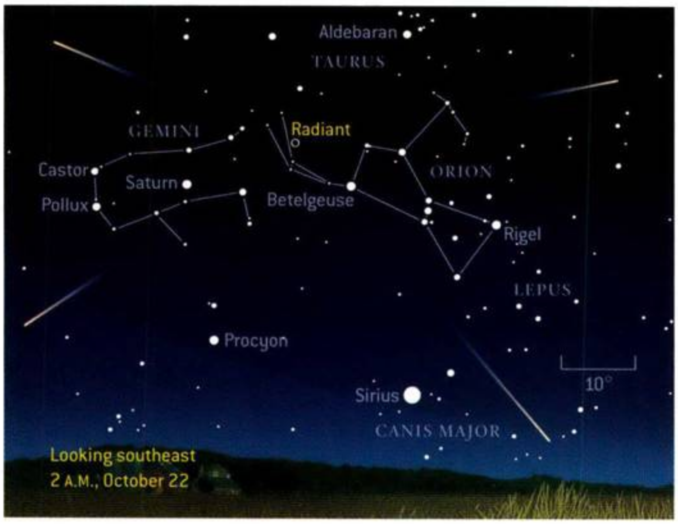
Looking east
30 minutes before sunrise, October 1

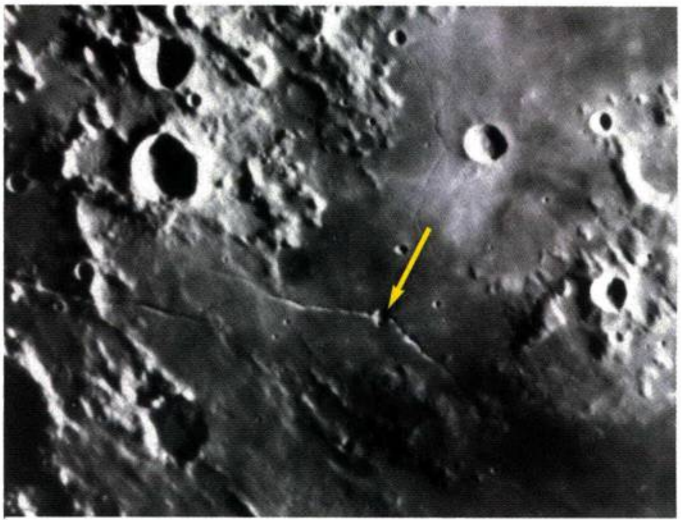
**Mercury** appears briefly in the eastern sky before dawn in early October. It reached greatest western elongation from the Sun on September 26 and continues to be visible before sunrise for a short period. On October 1, Mercury rises 85 minutes before the Sun at mid-northern latitudes. It then shines at magnitude –0.8 and shows a 6.3"-diameter disk that appears two-thirds lit. Mercury quickly becomes consumed by the twilight glow after the first week of the month.

Daylight-saving time ends on October 26, when most locations in the United States fall back one hour. For observers, does this mean an extra hour of observing? Of course not. The length of darkness remains the same — our numbering of the hours simply changes. It does provide another hour of observing before bedtime, however.

# METEORS AND MOONS

A prominent annual meteor shower peaks with the Moon pretty much out of sight. When the Moon does return, look for an intriguing system of lunar rilles.





**THE HYGINUS RILLE** cuts a long, narrow path across the Moon's surface, forming a "V" shape centered on the crater Hyginus (arrow). CHRISTIAN ARSIDI

**AN ORIONID METEOR STREAKS** through Pyxis during the 1993 shower. Conditions for this year's shower should be similarly excellent. WALLACE BALDWIN

## The Hunter's shower

October's Orionid meteors represent the second of two annual showers associated with Comet Halley (the other is May's Eta Aquarids). Favorable conditions should greet meteor observers at the peak of this year's shower on the morning of October 22. The shower's radiant, which lies in the northern part of the constellation Orion, rises before midnight, while the waning crescent Moon doesn't poke above the horizon until nearly 4 A.M. local daylight time. This offers a good window of opportunity to observe the most active part of the shower.

Peak hourly rates can reach up to 25 meteors per hour — assuming the radiant lies overhead and the sky is pitch black. Normal observing conditions fall short of this ideal, and the actual number of observed meteors will likely be closer to a dozen per hour. Still, Orionid meteors tend to be bright and often leave persistent trains, making the view of even one meteor every five minutes worth staying up late or rising early. The meteors result when Earth plows into the stream of debris left behind by Halley. The debris smashes into the atmosphere at 41 miles per second, burning up and leaving the bright streaks we see in the sky.

## Moon feature: Hyginus Rille

Many observers rate the Hyginus Rille among their favorite areas on the Moon. The tiny crater Hyginus, centered along the rille, is easy to spot because of this association. The crater itself measures 6.6 miles across. The rille runs about 135 miles long and varies between 1 and 2 miles wide, cutting a shallow "V" shape across the terrain. A 2.4-inch (60mm) scope can reveal the rille. Larger scopes will be able to distinguish the sunlit wall from the shadowed one and show the variations in width along the rille's length. The entire region comes into view a day before First Quarter Moon, and sunset arrives a day before Last Quarter Moon.

Two large craters sit nearby: Agrippa and Godin. The Hyginus Rille sits in a small, flat valley adjacent to these craters. Other rilles also cross this area. The long, linear Ariadaeus Rille seems to connect with the Hyginus Rille. To the southwest, the complex Triesnecker rilles run from the eastern flank of the 16-mile-wide Triesnecker crater. Planetary scientists think rilles form when lava tubes collapse. Tiny craters and good-sized, individual mountain peaks dot this region, making it fascinating to study under low-light angles.

# COMETS AND ASTEROIDS

Comet paradise here we come — from the end of October through next June, we should have several nice comets to observe.

## Encke's evening romp

Backyard observers expect to be able to glimpse Comet 2P/Encke with the naked eye in late November, and this periodic dirty snowball should put on a fine telescopic show. The fun in October will be watching it rise from a challenge object to small-scope visibility.

The "2P" part of the designation for Encke signifies that it was the second periodic comet to have its orbit pinned down (after its famous cousin, Comet 1P/Halley). Encke typically provides a good show when Earth lies at the right spot in its orbit, as it does this year. Comet Encke has the shortest period of any known comet; it returns to the inner solar system every 3.3 years. The far end of its orbit reaches past the main asteroid belt, but at its closest, the comet swings just inside Mercury's path.

The best views of comets are made at sites away from city lights because their faint tails disappear behind the veil of skyglow. As luck has it, the bright light from the Moon disappears from the evening sky when Encke crosses the 10th-magnitude threshold, comparable in brightness to many Messier objects.

**COMET ENCKE RETURNS TO VIEW** in late October, the start of a brief — but excellent — apparition.

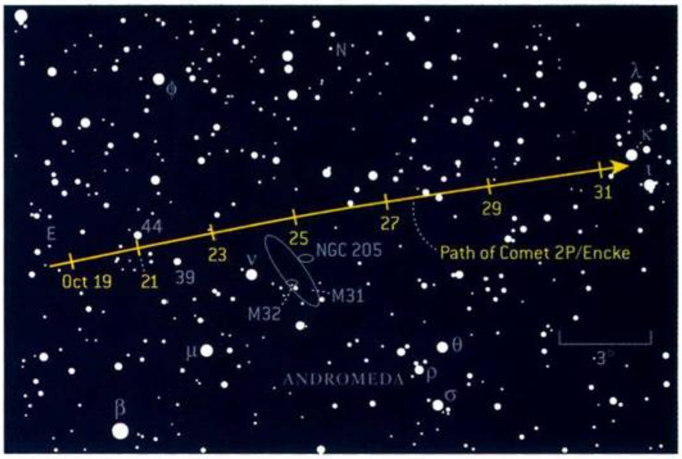
JIM SCOTTI (SPACEWATCH/UNIVERSITY OF ARIZONA)

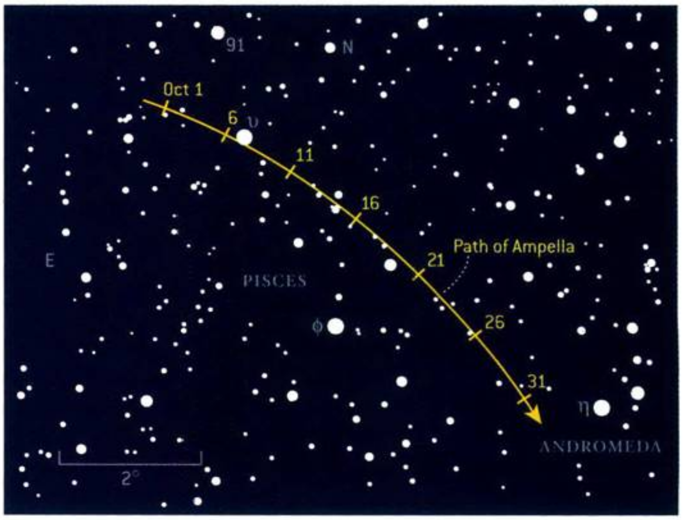
A perfect opportunity to observe Encke comes on the New Moon weekend of October 25, when it lies just 2° north of the Andromeda Galaxy (M31). The comet should be about 10th magnitude then, compared with the 8th-magnitude glow from M31's satellite galaxies, M32 and NGC 205.

You'll be hearing a lot more about Comet C/2002 T7 (LINEAR) in the months to come. Astronomers forecast it to reach naked-eye visibility from most backyards this coming spring. Right now, it's a dark-sky telescopic object in Auriga. It grazes past the gas cloud NGC 1931 on October 7, making for a nice CCD photo opportunity (the Moon's competing light will kill the visual appeal). Comet C/2001 HT50 (LINEAR-NEAT), glowing at 11th magnitude as it cruises near the Hyades, should also be on the comet hunter's list.

## A high number comes within reach

An asteroid's brightness usually echoes its rank on the discovery list. Exceptions to this rule occur when an eccentric orbit brings a small rock much closer to Earth than normal. Modestly high in number, the asteroid 198 Ampella glows at magnitude 10.3 this month. It lies not far from the Pinwheel Galaxy featured in the deep-sky section.





Use the low-power finder chart on page 61 to find Upsilon (υ) Piscium. Bump up the power on Upsilon and watch Ampella shift position over a couple of hours during the evenings of October 6 to 8. Ampella will take a couple of nights to pass through a triangle of 8th-magnitude stars on the 13th through the 15th. A sketch of the trio serves as a good reference for tracking the asteroid's motion.

A 4-inch telescope will pull Ampella out of the background sky unless you're close to a city's core. Discovered by French comet observer Alphonse Borrelly in 1879, Ampella is a fairly small minor planet that spans 40 miles. ■

# LUMICON

*. . . The Legend Continues*

## LUMICON FILTERS

**Lumicon International offers you the best and most extensive line of astronomical filters in the world. Filters for every imagined visual and astrophotographic application, in many configurations and sizes. Filters for deep-sky objects, galaxies, nebulae, planets, planetary nebulae, light-polluted skies, comets, and solar prominences. All UHC, Deep Sky, Oxygen III, and H-Beta filters are individually inspected and tested on a Perkin-Elmer Double-Beam Spectrophotometer. We proudly inscribe the % transmission for each of the primary lines. All made in the USA, and assembled in our new factory in California. All Lumicon International Products come with a 100% satisfaction guarantee. Please visit our website at: www.lumicon.com for further information.**

### LUMICON DEEP SKY FILTER

The Lumicon Deep-Sky Filter is THE foremost broadband filter, blocking ALL mercury-vapor as well as high & low pressure sodium-vapor lamp light, neon lights and airglow, while transmitting the rest of the visible spectrum. The superior contrast gain between the object you're viewing and the black background of space allows you to enjoy viewing galaxies, nebulae, star clusters, comets, etc. from light-polluted urban skies, making it the best all-around visual light pollution filter. Ideal for visual or photographic use.

.965" – $89.95 • 1.25" – $99.95 • Brandon 1.25" – $99.95 • 2" T-Threaded – $199.95 • 48mm – $199.95 • 72mm – $399.95 • Visual Back – $199.95 • 39mm Nikon – $299.95 • 43mm Nikon – $299.95

### LUMICON UHC FILTER

The original Lumicon Ultra-High-Contrast narrow bandpass filter (24nm) isolates the two doubly-ionized oxygen lines (496 and 501nm lines) and the H-beta line (486nm) emitted by planetary and most emission nebulae. The result is superb views of the Orion, Lagoon, Swan and other extended nebulae. This makes the Lumicon UHC the best all-around dark-sky nebular filter available.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

### LUMICON OXYGEN III FILTER

The renowned, original Lumicon OIII narrow bandpass filter (11nm) isolates just the two doubly-ionized oxygen lines (496 and 501nm lines) emitted by planetary and extremely faint nebulae. Produces near-photographic views of the Veil, Ring, Dumbbell and Orion nebula, among many other objects. You will be amazed at what the OIII filter allows you to see!

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back SCT – $199.95

### LUMICON HYDROGEN-BETA FILTER

The Lumicon H-Beta Filter isolates only the Hydrogen-Beta line of the spectrum (486.5nm). Now you can view extremely faint, special objects such as the Horsehead, Cocoon and California Nebulae. In many cases, the Lumicon H-Beta Filter is the ONLY way to view these objects. A steady, transparent sky, with a minimum of an 8" or larger instrument, combined with the Lumicon H-Beta Filter, all make an unbeatable combination for viewing those "notch in the belt" objects.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

### LUMICON HYDROGEN-ALPHA PASS FILTER, FOR BLACK AND WHITE DEEP-SKY PHOTOGRAPHY

The Lumicon H-Alpha Pass Filter is a powerful photographic aid in overcoming light pollution during deep-sky photography, and will help you achieve strikingly improved results in telephoto lens B&W astrophotography. It is ideally matched to hypersensitized 2415 film, and will reduce light pollution 10-fold, making it ideal for photography of faint emission nebulae.

Transmission for this sharp-cut-off filter is zero below 630nm, 90% at Hydrogen-Alpha 656nm, and 90-98% from 656nm to the near infrared. Both surfaces of filter have high-efficiency anti-reflection coatings to boost performance.

Exposures may be increased 2-10 times with the H-Alpha Pass Filter, depending on the faintness of the nebula.

48mm–$69.95 • 58mm–$79.95 • 77mm–$89.95 • 82mm–$99.95

### 48MM COLOR FILTERS

Used in lunar and planetary observing.

Red – $29.95 • Orange – $29.95 • Yellow – $29.95 • Green – $29.95 • Blue – $29.95 • Ultra-Violet (Clear) – $29.95 • Polarizer – $49.95 • Neutral Density – $39.95

1.25" lunar & planetary photo-visuals, world's best, coming soon.

### LUMICON MINUS VIOLET FILTER FOR COLOR OR BLACK AND WHITE PHOTOGRAPHY

The Lumicon Minus Violet Filter greatly improves photographs taken through lens systems, producing pinpoint star images. It is especially recommended for all telephoto lenses. This filter is made from optically flat specially-made colored glass, and has anti-reflection coatings on both surfaces.

**Recommended Films**

All films can be used with the Minus Violet Filter; hypersensitized 2415 is the recommended B&W film, and is available directly from Lumicon or from any of Lumicon's authorized dealers.

**Visual Use**

The Minus Violet Filter can eliminate or greatly reduce the blue halo sometimes seen around stars through refracting telescopes. It is ideal for observing the moon and planets.

48mm – $49.95 • 58mm – $59.95 • 72mm – $69.95

### LUMICON INFRARED BLOCKING FILTER

The Lumicon Infrared Blocking Filter completely blocks all infrared light above 750nm. Its versatile, anodized aluminum cell has 42mm male T-threads on one side and 48mm male threads with 42mm female T-threads, internal, on the other. Great for CCD camera infrared blocking purposes.

2" – $99.95

Infrared Blocking Filter 1.25" coming soon.

### LUMICON UV DUST SEAL FOR MOST SCTs

The Lumicon UV Dust Seal keeps dust and insects out of your telescope. The seal mounts on the back of your SCT and accepts all attachments. It is an ultraviolet filter that passes all visible wavelengths of light with minimal absorption, no aberration, and no noticeable internal reflections. Fully Multi-Coated.

5-9.25" SCT / Mak – $39.95 • Meade 10/12/14" – $89.95 • Celestron 11/14" – $89.95

### LUMICON COMET BAND FILTER

Lumicon's narrow visible bandpass (25nm) Comet Band Filter isolates the 501nm OIII and the 514nm Cyanogen lines. The high contrast gain of the filter reveals the delicate ionized tail of gaseous comets, allowing you to see their full extent. The Comet Band Filter also helps you to better distinguish gaseous comets from dusty comets which show little contrast gain. For dusty comets, use the **Lumicon Deep Sky Filter**.

Howard Brewington, famed comet discoverer says: "I discovered Comet Aarseth-Brewington, 1989a1, using the Lumicon Comet Band Filter. The filter doubled the contrast, making the comet very easy to spot." Be the person to discover the next "Comet of the Century" using the Lumicon Comet Band Filter.

1.25" – $99.95 • Brandon 1.25" – $99.95 • 48mm – $199.95 • Visual Back – $199.95

### SOLAR PROMINENCE FILTERS

The 1.5 Ang. Lumicon Solar Prominence Filter system lets you see the awe-inspiring solar prominences jutting off the edge of the sun. Sunspots and bright filaments can also be seen on the sun's surface. The filter has a 2" barrel for insertion into 2" focusers, and can be easily adapted for 1.25". It also has camera T-threads and a viewing adapter for 1.25" eyepieces.

Solar Prominence Filter $699.95 • 58mm Energy Reject Prefilter – $169.95 • 77mm Energy Reject Prefilter – $199.95

Off-Axis Mask for 8" SCT – $69.95 • Off-Axis Mask for Meade 10" – $89.95 • Off-Axis Mask for C11 – $99.95 • Off-Axis Mask for 12" LX200 – $99.95 • Off-Axis Mask for C14 – $119.95 • Off-Axis Mask for M14 – $119.95 • Off-Axis Mask for 16" LX200 – $129.95

### MULTIPLE FILTER SELECTOR

The Lumicon 1.25" Multiple Filter Selector lets you switch instantly back and forth between your Lumicon 1.25" filters without having to constantly thread and unthread them from your eyepieces. You may leave one of the 5 slots open to compare filtered and non-filtered views. – $129.95

## EASY GUIDERS

All of Lumicon's famous off-axis guiders feature Lumicon's patented radial and rotational off-axis adjustments – combined with a large off-axis pick-off prism, making bright guide star selection a breeze.

### CASSEGRAIN EASY GUIDER FOR 7" TO 9.25" SCTs

The Lumicon Cassegrain Easy Guider allows off-axis guiding with your Cassegrain telescope, reducing the f-ratio from f/10 to f/6.3 with a large, fully-coated focal reducing lens. The faster f-ratio, combined with the ease of finding and guiding on bright guide stars, minimizes guiding error, making for successful astrophotos. Threaded for 48mm filters. Specify camera type when ordering.

Celestron 5 – $249.95 • 7" Mak – $249.95 • 8" SCTs – $249.95 • Celestron 9.25" – $249.95

### GIANT EASY GUIDER FOR 10" TO 16" SCTs

The Lumicon Giant Easy-Guider is a powerful photo/visual tool, utilizing an 80mm multicoated compression lens, reducing the f-ratio from f/10 to f/6.3, allowing you to take full advantage of your telescope's capabilities. Ideal for 35mm and 120 format film with 100% edge-to-edge illumination and pinpoint star images. All other off-axis guiders have prisms and focal reducing lenses a fraction the size of the Lumicon Giant Easy Guider's. Threaded for all Lumicon 48mm filters. Specify camera type when ordering.

10", 12", 14" and 16" Meade – $399.95 (Meade 16" LX200 requires adapter - $169.95) • 11" and 14" Celestron – $399.95

### NEWTONIAN AND REFRACTOR EASY GUIDER

The Lumicon Newtonian and Refractor Easy Guiders allow off-axis guiding directly through the main telescope, thus preventing differential flexure between telescope and guide scope that can ruin your astrophotos. Low-profile design installs in seconds into 1.25" and 2" focusers. Threaded for 1.25" and 48mm filters. Specify camera type when ordering.

1.25" and 2" Newtonian – $189.95 • 1.25" and 2" Refractor – $189.95

### LUMICON EASY GUIDER ACCESSORIES

- Newtonian Easy-Guider Focal Reducer Lens in Cell – $79.95
- Giant Easy-Guider Focal Reducer Lens in Cell – $199.95
- Giant Easy-Guider - No Lens – $319.95
- Cassegrain Easy-Guider - No Lens – $219.95

### LUMICON 3X RELAY DIAGONAL FOR USE WITH EASY GUIDERS

Lumicon Relay Diagonal's 3x Barlow lens increases the guiding magnification in the off-axis portion of your Lumicon Easy-Guider, increasing off-axis guiding ease and precision. – $99.95

## HYPER KITS

### LUMICON FILM HYPERSENSITIZATION KITS

Film hypersensitization with a Lumicon Hyper-Kit super-dries your film's emulsion using nitrogen and hydrogen (Lumicon's Forming Gas: 8% prepurified hydrogen, 92% prep. nitrogen, removing ALL water vapor and oxygen molecules, thus thermally stabilizing the film's emulsion. The process also 'soaks' the emulsion with hydrogen, thus sensitizing the silver halide crystals, making them more sensitive to faint light. The combined effect reduces reciprocity failure of the film, allowing it to remain sensitive to light well beyond an hour instead of only a few minutes. Hypered film is a MUST for anyone who is serious about taking deep-sky photographs.

### LUMICON MODEL 300 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

For simplest hypering with film still in its metal cassette, the Model 300 Hyper-Kit is easy in use and safe for your film. Operates with Lumicon's Forming gas at 30° C. Hypers film in two to five days.

Chamber Only – $249.95 • Film Hyper Kit – $375.95 • Hyper Kit O-Ring Set – $9.95

### LUMICON MODEL 600 FILM HYPERSENSITIZATION KIT FOR 35MM AND 120 FILM

The versatile Lumicon Model 600 Hyper-Kit is capable of hypering film either while still in its metal cassette at 30° C, or more quickly with highest saturation on the open reel at 50° C. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas.

Chamber Only – $299.95 • Film Hyper Kit – $475.95 • Hyper Kit O-Ring Set – $9.95 • Hyper Kit Hand Vacuum Pump – $39.95 • Hyper Kit Vacuum Pump Handle – $9.95

### LUMICON MODEL 1200 FILM HYPERSENSITIZATION KIT FOR 35MM, 120, AND 4x5 FILM

Large-capacity Lumicon Model 1200 Hyper-Kit accepts 4x5 film. Kit is capable of hypering film in just 12-to-20 hours with highest saturation. Super-dries and sensitizes the film's emulsion with Lumicon's Forming Gas at either 30° or 50° Centigrade for simple or advanced modes of operation.

Chamber Only – $379.95 • Film Hyper Kit – $751.95 • 4x5 Plate Holders – $99.95 • Hyper Kit O-Ring Set – $9.95

### HYPER KIT ACCESSORIES

- 4x5 Sheet Film holder – $99.95
- 35L Cylinder of Forming Gas – $145.95
- 30° C Temperature Sensor Probe – $99.95
- 50° C Temperature Sensor Probe – $99.95
- Temperature Controller – $139.95 • Electric Vacuum Pump – $349.95 • 220 V option on Vacuum Pump – $44.95 • 220V/110V Converter – $29.95 • Vac/Pressure Hose with Clamp – $9.95

## ASTROPHOTOGRAPHY FILM

### HYPERED FILMS

Use Lumicon Hypersensitized Film to take stunning astro photographs. Allows you to expose film on your favorite deep sky object far longer, with no fog buildup, than does non-hypersensitized film.

Fuji G800 – $19.95 • Fuji RD100 – $14.95 • TP2415 B&W – $19.95 • TP6415, 120 – $19.95 • Kodak P1600 – $24.95 • Kodak PPF400 – $19.95 • Kodak PPF400, 120 – $19.95

### NON-HYPERED FILM

Lumicon's high-contrast, extremely fine-grained film. High quality for medium-format astrophotography.

TP2415, Bulk 150' Roll – $79.95 • TP2415, Normal 36 exposure – $11.95 • TP4415, 4x5" Normal 25 Sheets – $49.95 • SO-279 Vericolor Slide Film – $14.95 • Kodak 6415, Normal Film – $9.95 • Fuji G800, Normal Film – $9.95 • PPF400, 120, Normal Film – $11.95 • PPF400, 120, Normal Film - 5 pack – $49.95 • Kodak P1600, Normal Film – $19.95 • Fuji Sensia RD100, Normal Film – $9.95

### FILM DEVELOPING MATERIALS

- Film Changing Bag – $ 16.95
- Kodak D19 B&W Developer – $ 19.95
- Patterson film developing tank – $19.95

# DIAGONALS

### ENHANCED ALUMINUM STAR DIAGONALS

The Lumicon Enhanced Aluminum Star Diagonal reflects 96 to 97 percent of the light from the telescope's primary optics into your eyepiece. Its single 1/10 wave precision-polished surface is superior to the three surfaces of prism diagonals, and its enhanced coating is more durable than a standard aluminum coating. Lumicon collimates each star diagonal using a double-pass collimator, ensuring that the light reflected from the diagonal is perfectly perpendicular to the telescope's optical axis.

1.25" – $99.95 • 2" – $189.95

### LUMIBRITE STAR DIAGONAL

The Lumicon LumiBrite Dielectric-Coated Diagonal reflects >98 percent of the light from the telescope's primary optics into your eyepiece. Not only is the Dielectric Coating more durable than a standard aluminum coating, it is also smoother, resulting in higher image contrast. 1.25" – $149.95 • 2" – $239.95

# SKY VECTOR

The Lumicon Sky Vector is a state-of-the-art digital setting circle system, providing virtually any astronomical telescope, whether equatorial or altazimuth, with a continuous, real-time digital readout of right ascension and declination coordinates. With the Sky Vector, you will be able to find objects even faster than with most fully computer-driven telescopes. Its alphanumeric display uses a simple, easy-to-read scrolling text format. There is no need to polar align or to enter Latitude, Longitude, Date, Altitude, and Sidereal time – just initialize on one or two stars and you're ready to go!

### SKY VECTOR 1

The Lumicon Sky Vector 1 features: One- or two-star initialization; 4000-step encoders for high-resolution accuracy (0.09 deg.); Digital Right Ascension coordinate readout to 1 minute; Digital Declination readout to 10 arc-minutes; Guide mode for guiding you to the selected object in current memory; Database containing over 220 of the finest objects in the sky, including the famed "Messier Catalog."

Complete Set – $349.95 • Kit only – $269.95

### LUMICON NGC SKY VECTOR

The Lumicon NGC Sky Vector has all the features of the Sky Vector 1, plus a large 12,000-object database, higher resolution display modes, IDENTIFY mode, and current constellation and chart number displays - all on a 16-digit red LED display. It can be integrated with a personal computer for display of celestial object coordinates.

Complete Set – $489.95 • Kit only – $419.95 • Serial Cable – $29.95

### SKY VECTOR UPGRADES

- Upgrade 3.65 Chip Set for NGC Sky Vector. – $59.95
- 8192-Step Encoder (Set of 2). Can be purchased separately or in place of the standard 4000 step encoders. – $29.95

### LUMICON SKY VECTOR HARDWARE PACKAGES

Lumicon Sky Vector Hardware Package for Meade and Celestron SCTs includes: declination encoder bracket, right ascension encoder holder, encoder shaft holders, Allen wrench, and instructions.

Lumicon Sky Vector Hardware Package for Dobsonian telescopes includes: brass azimuth bolt, stainless steel azimuth encoder bracket, aluminum altitude-encoder-shaft holder, stainless steel altitude encoder bracket, 10 wood screws, Allen wrench, and instructions.

C5+ – $79.95 • C8 – $69.95 • Celestar 8 – $79.95 • Celestar 8 Dlx – $79.95 • G8/G11 – $349.95 • Ultima 8 – $79.95 • Ultima 11 – $99.95 • C11 – $79.95 • C14 – $129.95 • Meade 2080 – $69.95 • 2120 – $79.95 • 8" Dob – $69.95 • 10" Dob – $69.95 • 12/13" Dob – $79.95 • 16/17" Dob – $89.95 • CI700 – $299.95

# RICHFIELD VIEWERS

### RICHFIELD VIEWER FOR 7" TO 9.25" SCTs

The Lumicon Richfield Viewer takes your Schmidt-Cassegrain's f/10 optics and reduces them to f/6.3 for beautiful wide-field views. Its fully-coated 50mm diameter focal reducing lens has a larger clear aperture and less coma than higher-priced focal reducers on the market, providing superb unvignetted views. Barrel accepts 2" star diagonals. Comes with an aluminum 2"-1.25" eyepiece reducer, threaded for 48mm filters. – $99.95

### RICHFIELD VIEWER, THREADED FOR 7" TO 9.25" SCTs

Threads directly into telescope. – $99.95

### RICHFIELD VIEWER, SLIDE-ON, FOR 7" TO 9.25" SCTs

For attachment onto SCTs that have the Lumicon Easy-Guider threaded attachment ring in place. Slides over attachment ring. – $99.95

# GIANT RICH-FIELD VIEWERS

### LUMICON GIANT RICH-FIELD VIEWER FOR LARGE SCTs

Takes your large Schmidt-Cassegrain f/10 optics and reduces them to f/6.5 for the widest possible views of large galaxies like M31, M33 and NGC 253, and pairs of galaxies like M81 and M82. Moving the 80mm diameter focal reducing lens to the forward position in the Rich-Field Viewer body yields an even wider field. Comes with a 2"-1.25" eyepiece reducer, threaded for 48mm filters.

10" SCTs – $279.95 • Celestron 11" – $279.95 • 12" SCTs – $279.95

### LUMICON 2.5X CCD COMPRESSOR

This cost-effective, fully-coated lens widens the telescope field and yields pinpoint star images for small to medium-size CCD cameras. Has male threads for standard 1.25" eyepieces or camera-type barrels. – $129.95

### LUMICON 48MM COMA CORRECTOR/FIELD FLATTENER FOR NEWTONIAN EASY GUIDER OR 2" EYEPIECE

The Lumicon Coma Corrector / Field Flattener Lens dramatically reduces coma and flattens the field when used, in particular, with f/3.5 to f/6 Newtonian telescopes. It makes off-axis star images much smaller, thus improving photographic quality and making guiding much easier. Free of all chromatic aberration and fully multicoated to prevent ghost images. Can be used on all 48mm threaded accessories. Neither shrinks nor magnifies the image. – $239.95

### LUMICON 1.5x–1.8x MULTIPLIER/FIELD FLATTENER

The Lumicon Multiplier / Field Flattener Lens has been custom computer-designed to increase image scale with the flattest field possible for photography and visual use with fast Newtonian Telescopes. This lens is suitable for use with f/3.5 to f/6 systems. Fully multicoated for maximum light transmission. – $259.95

# FINDERSCOPE

Lumicon 80mm SuperFinder for Right-Angle viewing. This finder telescope actually lets you see many of the deep-sky objects you are looking for, complementing any telescope having 8 or more inches of aperture. It also makes for a wonderful rich-field telescope for beautiful views of the Milky Way. Comes with 25mm, 1.25" cross-hair eyepiece and helical drawtube-type focuser.

50mm RA Finder - Body Only – $79.95 • 50mm RA Finder - Complete – $149.95 • 50mm Straight-Thru Finder - Body Only – $79.95 • 50mm Straight-Thru Finder - complete – $119.95 • 80mm Right Angle SuperFinder - Body Only – $199.95 • 80mm Right Angle SuperFinder with Tripod Block – $219.95 • 80mm Right Angle SuperFinder - Complete – $299.95 • 80mm Straight-Thru SuperFinder - Body Only – $199.95

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- Universal Dovetail Bracket for 50mm finder – $39.95
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### LUMICON 25MM CROSS-HAIR FINDER EYEPIECE

This well-made 25mm, 1.25" Kellner single-crosshair finderscope eyepiece is ideally suited for Lumicon's 50mm and 80mm SuperFinders. High contrast and flat field. Non-illuminated. – $69.95

# GUIDING EYEPIECE

### LUMICON GUIDING EYEPIECE WITH RETICLE ILLUMINATOR

Lumicon's top-quality 12.5mm, 1.25" Orthoscopic eyepiece with focusable dual cross hair for precision guiding. Incorporates new state-of-the-art cordless Reticle Illuminator, featuring rheostatic brightness control and on/off switch.

12.5mm, 1.25" Illuminated Reticle E.P. – $149.95 • Pulseguider Illuminator – $42.95

# BINOVIEW

### LUMICON BINOVIEW

These new high-quality German-made binoviews employ Grade-A BK 7 crown glass for its precision-polished prisms. Ordinarily, BaK 4 is used as a recourse to improve color correction, but in these binoviews color correction is so good that we may use the most transparent, homogeneous, bubble-free crown glass available – BK 7. Clear aperture is 22mm. Its straight-through design employs superior roof prisms for image erection. Each prism surface is multicoated for the highest transmission of light and freedom from ghosts. Focuser travel is 20mm. – $699.95

# VISUAL AND PHOTOGRAPHIC ACCESSORIES

### PHOTOGRAPHIC ADAPTERS

1.25" Prime Focus Adapter – $24.95 • 2" Accessory Adapter for Celestron Classic Refractors – $39.95 • 2" Accessory Adapter for Celestron Fluorite Refractors – $39.95 • .96" Prime Focus Adapter – $19.95 • Basic Camera Adapter 1.25" – $39.95 • Basic Camera Adapter .965" – $39.95 • Adapter to mount Mamiya 645 Camera to 2" – $149.95 • 2" to T-thread adapter – $29.95 • Tele-Extender – $29.95

### VISUAL ADAPTERS

1" Thread-in extension tube, 1.25" – $19.95 • 1.25" Focuser to .96" Eyepiece Adpter – $24.95 • 2" Length drop-in Extension Tube 1.25" – $19.95 • 4.5" Length Drop-in Extension Tube, 1.25" – $29.95 • 2" Long Thread-in Extension tube, 2" Diameter – $24.95 • 2" Long, 2" Diameter Drop-in Extension Tube – $24.95 • 3" Long, 2" Diameter Drop-in Extension Tube – $24.95 • 2" to 1.25" Reducer – $24.95 • 2" Accessory Adapter for C6 – $39.95 • 2" Accessory Adapter for Schmidt Cassegrains – $39.95 • 2" Accessory Adapter for Celestron Classic Refractors – $39.95 • 2" Accessory Adapter for Celestron Fluorite Refractors – $39.95 • Adapter for .96" focuser and 1.25" Eyepiece – $24.95 • f/10 Viewing Adapter for Giant Easy Guider – $89.95 • Adapter for Meade 2" Thread-on diagonal to Cass. Easy Guider – $39.95 • Adapter for Meade 2" Thread-on diagonal to Giant Easy Guider – $49.95 • Adapter to hold 1.25" Eyepiece on T-thread – $29.95 • Adapter to hold 2" eyepiece on T-thread – $49.95

### EASY GUIDER ADAPTERS

Adapter to mount Hasselblad Camera to Giant Guider – $449.95 • Adapter to mount Pentax 645 Camera to Giant Guider – $169.95 • Adapter to mount Pentax 6x7 Camera to Giant Guider – $149.95 • 16" LX200 adapter for Giant Guider – $169.95 • Adapter to mount Hasselblad Camera to Cass. Easy Guider – $349.95 • Adapter to mount Pentax 645 Camera to Cass. Easy Guider – $159.95 • Adapter to mount Pentax 6x7 Camera to Cass. Easy Guider – $139.95

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# MISCELLANEOUS ACCESSORIES

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### LUMICON LUMILITE RED LED FLASHLIGHT

The Lumicon Red LED Flashlight not only provides the proper illumination for star atlases, but also for walking in the dark when held at or below belt level. Has built-in resistor for energy conservation – If you accidentally leave it on when you pack up, its batteries will still be almost as good as new in the morning! Great for astronomers, submariners or pilots who need to preserve their night vision. – $14.95

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Lumicon 2x Barlow 1.25" – $39.95
Lumicon 2x Barlow 1.25" Thread-in – $79.95

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Self-locking 12" Camera Cable Release for timed exposure. This high quality vinyl-covered cable release prevents camera shutter vibrations on long exposure photographs – a must for astrophotography. – $19.95

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**ENHANCED** Aluminum >96% reflectivity.

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# ASK ASTRO

Globular clusters, Beetlejuice, Full Moon rising

## GLOBULAR CLUSTERS

I have been wondering how globular clusters can survive. Given such a high density of stars and their gravity, why don't they attract each other and get crushed together? — **AKIRA HORIGUCHI,** TOKYO, JAPAN

**THE GLOBULAR CLUSTER M15** in Pegasus may contain a medium-mass black hole, a result of having had its core at least partially collapse. NOAO/AURA/NSF

Astronomers estimate the Milky Way Galaxy contains about 200 globular clusters, of which 147 are known. Born roughly 12 billion years ago, these spherical star systems occupy the galactic halo, the oldest part of our galaxy.

Globulars hold anywhere from a few thousand stars up to the million or so contained in such wonders as Omega Centauri and 47 Tucanae. In a typical globular, stellar density starts low near the edge of the cluster and climbs precipitously toward the center, where as many as a thousand stars may be packed into a cubic light-year.

So what keeps these clusters from collapsing? Basically, a globular does not collapse because all its stars orbit a common center of mass, and, in general, they maintain their relative positions.

Over time, however, they *do* collapse, but the process runs very slowly. The stars within a globular constantly interact through gravitation. When two stars encounter each other, on average the star with less mass draws energy from the more massive star and gets kicked toward the outside of the cluster. If the low-mass star moves far enough from the center, it can be lost from the cluster altogether. The gravitational pull of our galaxy raises tides in globulars, aiding in this ejection process.

As a globular cluster ages, its higher-mass stars sink to the center and the lower-mass stars are removed, one by one. Thus, the cluster collapses slowly toward its center at the same time it disintegrates. Some clusters actually seem to have undergone a kind of core collapse — astronomers suspect that M15 in Pegasus, for example, has a medium-mass black hole in its center. Even when a globular cluster does not centrally collapse, it can come very close.

Total collapse, however, is prevented by the formation of double stars, whose mutual orbits act like batteries that store energy. If the star density in the center of the cluster becomes high enough, close gravitational encounters can form binary star systems. The orbital energy of the binaries may then give a kick to single stars that encounter them. This "fluffs out" the cluster and slows the collapse.

The results of this action yield the gorgeous and varied globular clusters we see today. — **JIM KALER,** UNIVERSITY OF ILLINOIS

## BEETLEJUICE

**I am looking for a good reference that gives the preferred pronunciations of the stars and constellations. They all seem to be Latin, Arabic, or Greek.**
— **DICK SCHREIBER,** OAK RIDGE, TENNESSEE

These names have no official pronunciation, and indeed, you'll overhear an almost infinite number of variations at any star party. Most comprehensive and unabridged dictionaries provide pronunciations, although they differ somewhat from one to the next. Backyard astronomers, however, probably most often use the *Observer's Handbook*, published by the Royal Astronomical Society of Canada (www.rasc.ca). This is an annual guide to skywatching whose core is a month-by-month diary of celestial events.

The *Handbook* was first published in 1911, and like a protostellar cloud, it has steadily accreted extra tables, lists, and essays on topics such as telescopes and eyepieces, the visibility of planets, nearby galaxies, the Messier list, and so on. Now some 300 pages long, it forms a handy, popular astronomy reference book. Tucked among the extras are lists of stars, constellations, planets, and moons — with their pronunciations.

Are the pronunciations authentic? Well, who's to say? You note that the names derive from other languages. In truth, it's not likely that a native speaker of these languages would recognize a given Arabic- or Latin-based celestial name as spoken by one of us today. Star names, most of which derive from Arabic, have suffered the greatest distortion, largely because Europe's astronomers in the Middle Ages and Renaissance forced most Arabic names and words into a "Latinized" mold.

But even the Latin pronunciations given in the *Handbook* don't generally follow what scholars now believe was the pronunciation in antiquity. Instead, they fall somewhere between Church Latin and what an ordinary English speaker might guess when seeing the word for the first time. Thus, the *Handbook*'s pronunciation would have you say the name of Caelum the Chisel as SEE-lum, not KYE-lum as you're taught to say in first-year Latin class. And Betelgeuse? The *Handbook*'s preferred way comes out closer to BETTLE-jooz than BEETLE-juice, but popular usage generally prefers the latter.

In one regard, however, English-speaking constellation lore is highly mindful of its sources. We preserve classical constellation names in their Romanized form. In contrast, Europeans translate many star-figure names into their local language. For example, German constellation maps often label Ophiuchus as Der Schlangenträger ("the Snake Carrier"), while French maps show Canis Major as Le Grand Chien ("the Big Dog").
— **ROBERT BURNHAM,** CONTRIBUTING EDITOR

**THE FULL MOON RISES** at a different position from one year to the next because the Moon's orbit changes orientation over a period of 18.6 years. TRUDY KOLLER ANES

### FULL MOON RISING

**On January 12, 1998, the Full Moon rose directly behind a chalet on a crest of a mountain visible from my house. This year [2003] on January 18, the Full Moon rose about a hand-span held at arm's length farther north. Why such a dramatic difference?** — **KATJA FREEMANTLE,** ABERCORN, QUEBEC, CANADA

The direction of moonrise as seen from a given place depends both on the site's latitude and the Moon's declination, its distance north or south of the celestial equator. During the year, the Sun's declination varies between 23.5° north and south, but the Moon's declination follows a more complicated pattern. This occurs because the Moon's orbit inclines about 5° to the ecliptic, the Sun's apparent annual track in the sky. In addition, the nodes of the lunar orbit — the points where the orbit crosses the ecliptic — precess over a period of 18.6 years. As a result, the Moon's maximum declination limits vary between about 18.5° and 28.5° (north and south) over a period of almost 19 years.

In your case, the January 1998 Full Moon occurred in Gemini before the Moon reached its ascending node, which was then in Leo. The Moon at the time was about 4° south of the ecliptic. In January 2003, the Full Moon again occurred in Gemini, but by then, the node had precessed into Taurus. This put the Moon 4° *north* of the ecliptic. Thus, when the Full Moon rose, it was displaced noticeably northward on the horizon from the point where it rose in January 1998.
— **GEOFF CHESTER,** U.S. NAVAL OBSERVATORY

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Finally, a telescope that gives views that will blow you away without blowing your budget! A full 8" (203mm, f/4.9) parabolic primary mirror, which gathers 73% more light than a 6". The tube features a 2" aluminum rack-and-pinion focuser and a sturdy 4-vane holder. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), collimation cap and dust-cap.

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Love refractors? We've combined our 120mm achromatic refractor with our super-sturdy SkyView Pro mount. The big fully multi-coated 120mm (f/8.3) objective lens and 2" focuser will give you jaw-dropping views of the skies. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces (25mm and 10mm), 90° star diagonal, collimation tool and dust-cap.

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Given the popularity of our 127mm Mak, it's only natural that we offer it with the best new mid-sized equatorial mount in the market, the SkyView Pro. The 5" Maksutov-Cassegrain optics pull in plenty of light for great views of deep-sky gems. And you can't beat its long focal length of 1540mm (f/12.1) for high-magnification study of the moon and planets. Includes 6x30 finder scope, two 1.25" Sirius Plössl eyepieces, (25mm and 10mm) 90° mirror star diagonal, optical tube carry case and dust-cap.

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*Steel tube, 114mm center marked mirror (f.l. 910mm, f/8), 1.25" aluminum R&P focuser, 5" flanged altitude hubs, CorrecTension Friction Optimization, built in handle, dust cap, Weight: 17.2 lbs. (tube and base). Now With: 6x26 correct-image finder scope, 25mm (36x) and 10mm (91x) Sirius Plössl eyepieces, navigation knob, eyepiece rack, and collimation cap.*

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*Steel tube, 150mm center marked parabolic mirror (f.l. 1200mm, f/8), 1.25" aluminum R&P focuser, 6x30 achromatic finder scope, eyepiece rack, navigation knob, 5" flanged altitude hubs, CorrecTension Friction Optimization, dust cap, Weight:38 lbs. Now with: 25mm (48x) and 10mm (120x) Sirius Plössl eyepieces (1.25"), navigation knob, and collimation cap.*

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### SkyQuest XT8
The XT8's prodigious performance on both solar system and deep-sky denizens have made it the telescope of choice for thousands of astronomers, from beginners to die-hard hobbyists.

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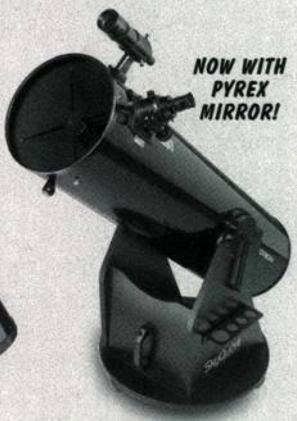
**$449**



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# ACCESSORIES

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### Orion V-Block™ Anti-Fringing Filter

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| | |
|---|---|
| **1.25" V-Block Filter** | **$69.95** |
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CELESTIAL PORTRAITS

*ASTRONOMY:* ROEN KELLY

# Tucana and Hydrus

In the Toucan and Little Water Snake, southern observers can sample deep-sky delights from our galaxy and beyond. /// BY TOM POLAKIS

For observers in the Southern Hemisphere, the spring months allow the Milky Way to swing below the South Celestial Pole while star-poor constellations reach their highest away from our galaxy's plane. Two of these constellations would be nearly devoid of interesting telescopic objects were it not for the presence of the Milky Way's closest significant companion galaxies.

Tucana the Toucan is an ill-defined sprinkling of mostly 4th-magnitude stars punctuated by 3rd-magnitude Alpha (α) Tucanae on its western border. Near the center of the constellation, Zeta (ζ) Tucanae is a Sun-like star just 28 light-years away that's racing across the sky at a rate of over 2" per year.

Hydrus the Little Water Snake is no match for Hydra, its much larger northern counterpart. The southern constellation contains three 3rd-magnitude stars. Their distances range from 24 light-years for Beta (β) Hydri to 210 light-years for Gamma (γ) Hydri.

The real gem of the region is the Small Magellanic Cloud (SMC), which owes its name to the Portuguese explorer Ferdinand Magellan. Together with the Large Magellanic Cloud (LMC), these companion galaxies are two of the most interesting and beautiful subjects in the nearby universe. Viewed without a telescope, the SMC measures 3° by 2°, is elongated northeast-southwest, and gradually brightens toward its core. At the northeastern end is a brighter region just under 1° across. Beta Hydri circles the South Celestial Pole 5° from the SMC's center.

The great distance to the SMC only began to be understood in the 1910s, when Henrietta Leavitt noticed a relationship between the luminosity and period of Cepheid variables. Scientists continue to determine distances with this method. The distance to the SMC is now given as 200,000 light-years, or 40,000 light-years farther than the LMC. The galaxy's classification remains uncertain, appearing in some sources as a peculiar barred spiral, while others call it a spheroidal with recent, but irregular, star formation. Past interactions between the two Magellanic Clouds are evident, with the most recent occurring 200 to 400 million years ago. This encounter created the SMC "Wing," a long tidal tail pointing from the eastern edge of the SMC toward the LMC. Numerous young stars and several of the SMC's brightest open clusters lie within this feature. The clusters are visible, but the string of faint stars is too dim for visual observation.

**THE SMALL MAGELLANIC CLOUD** holds several extragalactic targets for deep-sky observers.
LUKE DODD

Well away from the SMC, our first object, **NGC 7329**, can be found 2° southeast of Delta (δ) Tucanae. This barred spiral galaxy lies 150 million light-years away and is associated with IC 5250 to the north. In a 13-inch telescope, the galaxy is moderately faint, appearing 2' by 1' and elongated in position angle 150°. A slight, broad concentration of light brightens its center. Look for a 14th-magnitude star at its eastern end.

The **Tucana Dwarf** is best saved for very large telescopes at dark sites. This dwarf elliptical galaxy was first cataloged in 1985 and then rediscovered in 1990. At 2.8 million light-years away, it lies at a similar distance as the Andromeda Galaxy, but as a dwarf it is 30,000 times fainter than M31. I was unable to see it at an excellent site using a 13-inch scope, but a larger mirror and high magnification may bring out its dim form.

Our next target is a binary star with a period greater than 1,000 years. Located

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**Tom Polakis** *is an aerospace engineer who enjoys astrophotography and deep-sky observing.*

**NGC 7329** is a barred spiral galaxy located approximately 150 million light-years away in Tucana. DIGITIZED SKY SURVEY

**NGC 104 (47 TUCANAE)** is one of the most stunning globular clusters in the sky. Even naked-eye observers can spot it. MICHAEL STECKER

**NGC 121**, found just north of 47 Tucanae, is one of the oldest and brightest globular clusters in the Small Magellanic Cloud. DIGITIZED SKY SURVEY

just north of the SMC, **Kappa (κ) Tucanae** is a binary system whose two stars are separated by 5". Their separation and position angle will remain essentially constant during our lifetime. The two components are spectral types F6 and K2, which appear through the eyepiece as yellow-white and orange hues.

The bright globular cluster **NGC 362** lies in the direction of the SMC but is not associated with the cloud. Rather, it is seven times closer to us than the SMC. A 10-inch scope shows a well resolved ball of stars 5' in diameter. The core is very concentrated with a much brighter clump 10" across in the center.

We continue to skirt the SMC with one of the sky's most spectacular globular clusters, **NGC 104**. Popularly known as 47 Tucanae, it's bright enough to be seen easily as a fuzzy "star" with unaided vision. Telescopes as small as 60mm resolve its stars, some of which are brighter than 12th magnitude. The cluster comes to life in instruments with more than 6 inches of aperture. In such telescopes, 47 Tucanae looks like a ball of countless stars fully resolved to a center that peaks sharply in brightness. The very bright 2' core gets its light from thousands of unresolved stars. (Contrast this aspect of 47 Tucanae with the uniform ball of stars that is Omega Centauri.) Beyond a diameter of 6', streams of stars, including an especially prominent example to the south, appear to radiate from the cluster's center. The outlying stars bring 47 Tucanae's diameter to a half degree.

47 Tucanae's mere 15,000-light-year distance is a big reason it looks so bright. Several characteristics make it an exotic object: A dwarf nova resides 3" from the center; it contains a bright x-ray source; and it holds 20 "blue straggler" stars that vary with a common period. The cluster resides in the Milky Way's disk and has an orbit that carries it between 19,000 and 26,000 light-years from our galaxy's center.

Gaze to the north of 47 Tucanae's fringe stars to find our first SMC object, **NGC 121**. This globular cluster is one of the oldest in the Magellanic Clouds, but it is 2 billion years younger than the youngest Milky Way globulars. It's also the most luminous SMC globular. A large telescope shows a 2' haze with a brighter core. Its brightest stars are magnitude 17, so the cluster remains unresolved visually.

Northeast of the SMC's center sits one of the small galaxy's brighter open clusters with associated nebulosity. **NGC 371** is a loose scattering of several dozen stars nearly 10' in diameter. In a medium scope, a circular, ghostly nebula as large as the cluster overlaps the stars. Cataloged separately as Henize 1997, this bright object is enhanced greatly by a nebula filter.

NGC 371 forms a nice telescopic pair with **NGC 346**, an open cluster blanketed in the SMC's brightest nebula. The cluster's young stars ionize the surrounding hydrogen cloud, which is visible even in small binoculars. Visually, the nebula is most notable for its "barred spiral" form, which requires 8 inches of aperture to see. The bar is about 4' long and oriented roughly east-west. A thin, bright arm wraps around the south side from the eastern end of the bar, but the northern arm is more diffuse. The field is sprinkled with a dozen of the SMC's brightest stars.

Continuing another 20' toward the center of the SMC, **NGC 330** is a young open cluster holding stars as bright as magnitude 12.5. In a 16-inch scope, it looks like an oval globular cluster spanning 2' by 1' and containing a couple

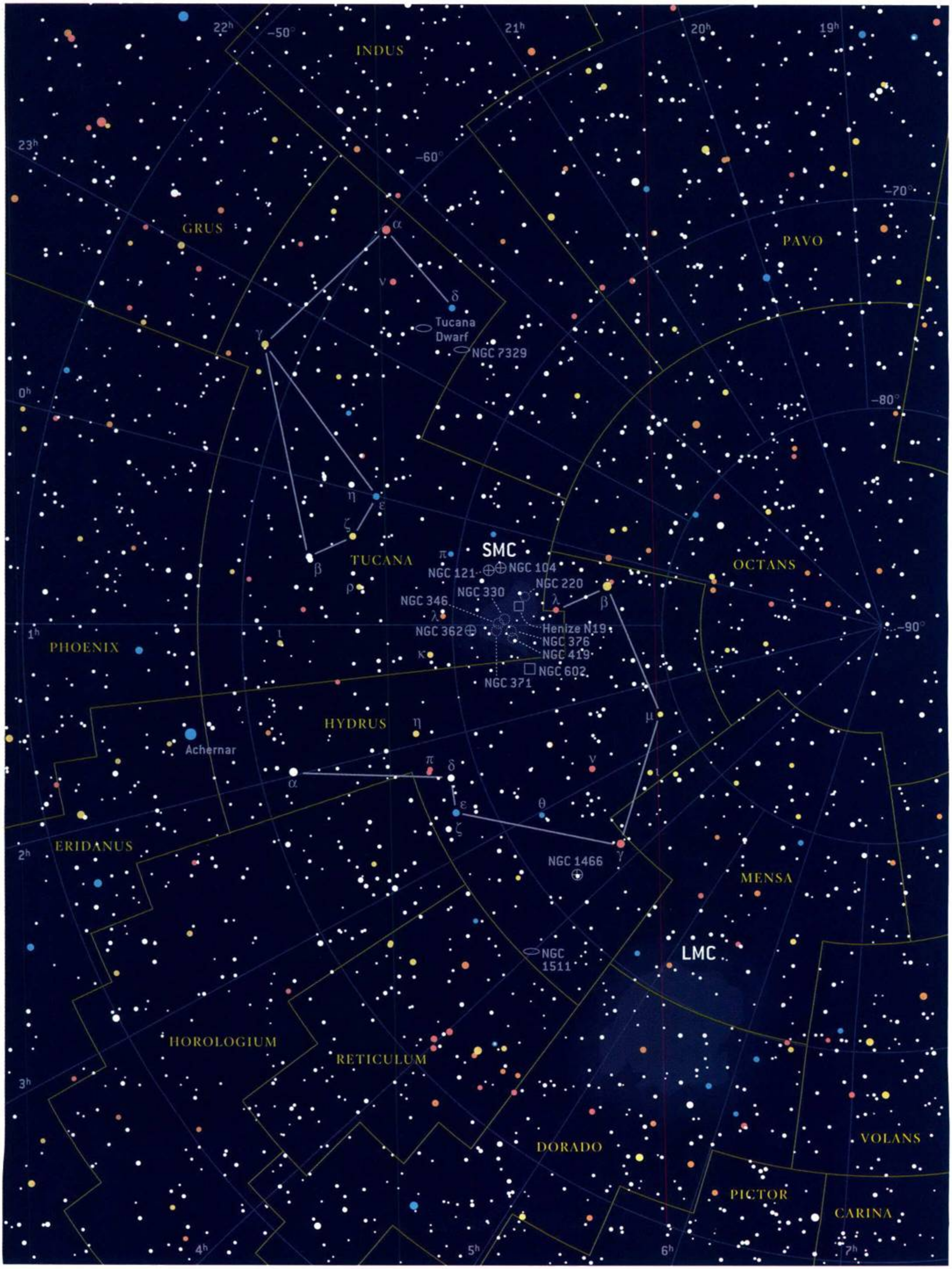
## /// THE TOUCAN AND THE LITTLE WATER SNAKE

*The snake is in his cave asleep;*
*The birds are on the branches dreaming;*
*Only the shadows creep;*
*Only the glow-worm is gleaming.*
Rosalind and Helen: A Modern Eclogue,
*Percy Bysshe Shelley (1792 – 1822)*

Tucana and Hydrus are both "modern" constellations, first recognized around the start of the 17th century. They were named by the Dutch navigators Pieter Dirkszoon Keyser and Frederick de Houtman during a journey to the East Indies from 1595 and 1597. German astronomer Johann Bayer included the two constellations in his 1603 sky atlas, *Uranometria*.

To Keyser and de Houtman, the small group of faint stars between the Large and Small Magellanic Clouds resembled a coiled snake with a raised head. Together, these stars became the southern cousin of the great Hydra in the north. The two water snakes joined several other large-and-small celestial pairings, such as the Great Bear and Little Bear (Ursa Major and Ursa Minor), the Lion and Little Lion (Leo and Leo Minor), and the Big Dog and Little Dog (Canis Major and Canis Minor).

Tucana flies the southern skies with several other birds, including Grus, Pavo, Apus, Columba, Corvus, and Phoenix. Its wide, kite-like shape reminded the Dutch navigators of the large-billed South American bird. However, some others, including Johannes Kepler and Italian astronomer Giovanni Riccioli, reportedly called the constellation "Anser Americanus," or the American Goose. — *Vanessa Thomas*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DORADO
VOLANS
PICTOR
CARINA
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5h
6h
7h

**NGC 371** contains several dozen loosely bound stars that are bathed in the glow of a faint nebula called Henize 1997. DIGITIZED SKY SURVEY

**NGC 346** is cataloged as an open cluster, but the SMC's brightest nebula accompanies the group of stars. DIGITIZED SKY SURVEY

**NGC 602** in Hydrus also includes a nebula and a cluster of stars. A dark lane splits the nebula down its middle. DIGITIZED SKY SURVEY

dozen stars superposed on a bright background haze. Note how abruptly this light fades into the background.

Like many star clusters in the Magellanic Clouds, **NGC 376** is classified as an open cluster, though it may be better described as a globular with young stars. Through the telescope, it appears only 30" across, but it does begin to resolve, showing a dozen stars of magnitude 14 across its face. The background haze is uniform with very little central concentration.

We move farther through the Wing of the SMC to find the star cluster **NGC 419**. At 2 billion years of age, it is another example of a young globular. Most of the luminous clusters in the SMC formed in two bursts 2 billion and 8 billion years ago. NGC 419 is one of the largest SMC globulars, appearing 2' wide in a 10-inch scope. Use your highest magnification to resolve some of the brightest members around the cluster's periphery.

Toward the southwestern end of the SMC, **NGC 220** highlights a trio of star clusters. It lies at the southwestern end of a line of clusters 4' long that includes NGC 222 and NGC 231. The physical separation between NGC 220 and NGC 222 is only 100 light-years. None of the clusters reveal individual stars, so they appear as small, circular, glowing patches.

Nudge the telescope a half degree to the northeast to land on a field that is busy with objects, most notably **Henize N19**. This is a circular HII region 5' wide that contains three supernova remnants. Centered in all of this is a very rich stellar association 350 light-years across. Use a nebula filter and a magnification that provides a one-degree field of view to see the crowding of at least ten emission nebulae.

Our final SMC object lies outside Tucana in Hydrus. **NGC 602** is an emission nebula with a cluster of stars. Using 215x and a nebula filter on a 13-inch telescope, I saw a circular haze 2' across with a dark, dividing lane in the center. A 12th-magnitude star shines at its southwestern edge.

Sandwiched between the two Magellanic Clouds, Hydrus houses outlying objects from both of them. **NGC 1466** sits 8° from the LMC's center, which corresponds to a projected separation of 22,000 light-years. It is an easy object for an 8-inch telescope, appearing about 1.5' across with a slightly brighter core. However, no stars are resolved. A 6th-magnitude foreground star shines 4' east of the cluster.

We finish with **NGC 1511**, an object that has no relationship with the Magellanic Clouds. This 12th-magnitude spiral galaxy lies 50 million light-years away and belongs to a small group including NGC 1473 and NGC 1511A. Two very faint stars flank NGC 1511. Seen from the edge, the galaxy appears 2.5' by 0.5' and uniformly bright except at its faint tips. NGC 1511 is home to a supernova that was seen in 1935, when it was mistakenly identified as a nova between the Magellanic Clouds. ■

### /// Deep-sky objects in Tucana and Hydrus

| OBJECT | R. A. | DEC. | MAG. | SIZE | TYPE | NOTES |
|---|---|---|---|---|---|---|
| NGC 104 | 0h24.1m | -72°05' | 3.8 | 30.9' | GC | 47 Tucanae |
| NGC 121 | 0h26.8m | -71°32' | 11.2 | 1.5' | GC | — |
| NGC 220 | 0h40.5m | -73°24' | 12.4 | 0.8" | OC | — |
| Henize N19 | 0h47.3m | -73°08' | — | — | BN | — |
| NGC 330 | 0h56.2m | -72°29' | 9.6 | 1.9' | OC | — |
| NGC 346 | 0h59.1m | -72°11' | 10.3 | 5.2' | OC | — |
| NGC 362 | 1h03.2m | -70°51' | 6.5 | 12.9' | GC | — |
| NGC 371 | 1h03.3m | -72°05' | — | 7.5' | OC | — |
| NGC 376 | 1h03.9m | -72°49' | 10.9 | 1.0' | OC | — |
| NGC 419 | 1h08.3m | -72°53' | 10.6 | 2.6' | OC | — |
| Kappa Tucanae | 1h15.8m | -68°53' | 5.1/7.3 | 5.4" | Dbl | — |
| NGC 602 | 1h29.6m | -73°33' | — | 3' | BN | — |
| NGC 1466 | 3h44.5m | -71°41' | 11.6 | 1.9' | GC | — |
| NGC 1511 | 3h59.6m | -67°38' | 11.1 | 3.5' by 1.3' | Gal | SAa pec |
| NGC 7329 | 22h40.4m | -66°29' | 11.8 | 3.2' by 1.9' | Gal | SB(r)b |
| Tucana Dwarf | 22h41.8m | -64°25' | 15.7 | 2.9' by 1.2' | Gal | E4 |

**Object:** Designation in NGC or other catalog. **R. A. and Dec.:** Right ascension and declination in epoch 2000.0 coordinates. **Mag.:** Visual magnitude. **Size:** Size in arcminutes or arcseconds. **Notes:** Hubble types for galaxies.

## MOON OBSERVER'S NOTEBOOK

Around First Quarter Moon, the Sun rises on a scene of great geologic variety. /// BY ROBERT BURNHAM

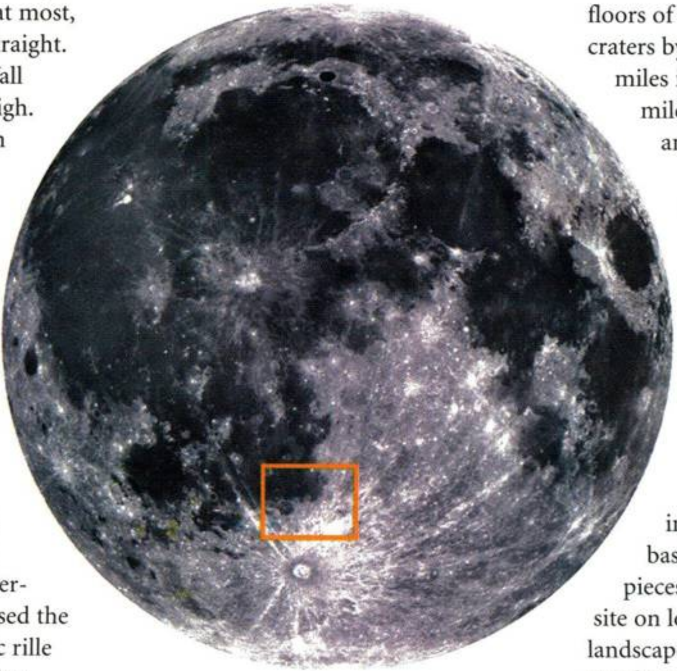
# The Straight Wall

The southeast corner of Mare Nubium lies far from the Moon's showpiece sites, such as the Apennine Mountains, the crater Copernicus, or the partly lava-flooded basin of Mare Nectaris. Yet this small region, where plains meet highlands, contains a variety of interesting geologic features — impact craters, lava-flooded plains, tectonic faulting, and debris from distant meteorite impacts — that are great for telescopic exploring.

A convenient place to begin is with the Straight Wall, officially known as **Rupes Recta**. This feature looks almost artificial, and pre-Space Age observers saw it as a steep cliff cutting across the Moon for 70 miles. The facts are somewhat tamer: The "wall" is a fault scarp that has a gentle 5° to 10° slope down to the west. From top to bottom, the altitude difference is, at most, 1,300 feet. And, it's not perfectly straight.

The shallow slope makes the Wall hard to identify when the Sun is high. Best views come at sunrise (as seen on page 77) and sunset, when the slope scribes a bright line. The Straight Wall lies within an unnamed "ghost" crater. Just inside this crater's eastern wall sits the 35-mile-wide crater **Thebit**. Its other rim is marked by a wrinkle ridge (in official terminology, a dorsum) southwest of **Birt**, an 11-mile-wide crater. View Birt at medium magnifications (100x to 150x) to see it best. The Wall may have fractured when the weight of lava floods covering the crater's western rim depressed the surface. **Rima Birt**, the little volcanic rille nearby, may reflect this stress. Farther west, more wrinkle ridges show where Mare Nubium buckled as its lava flows engulfed other craters.

Across Mare Nubium to the southwest lies **Pitatus**, an impact crater 60 miles in diameter. Note the partly breached rim on Mare Nubium's side and the tip of the crater's central peak. If the seeing is excellent, look for rilles that ring the lava floor of Pitatus, paralleling the crater's walls and lying just inside them. These features were produced by the uplifting of the crater floor after lava flowed in and filled it.



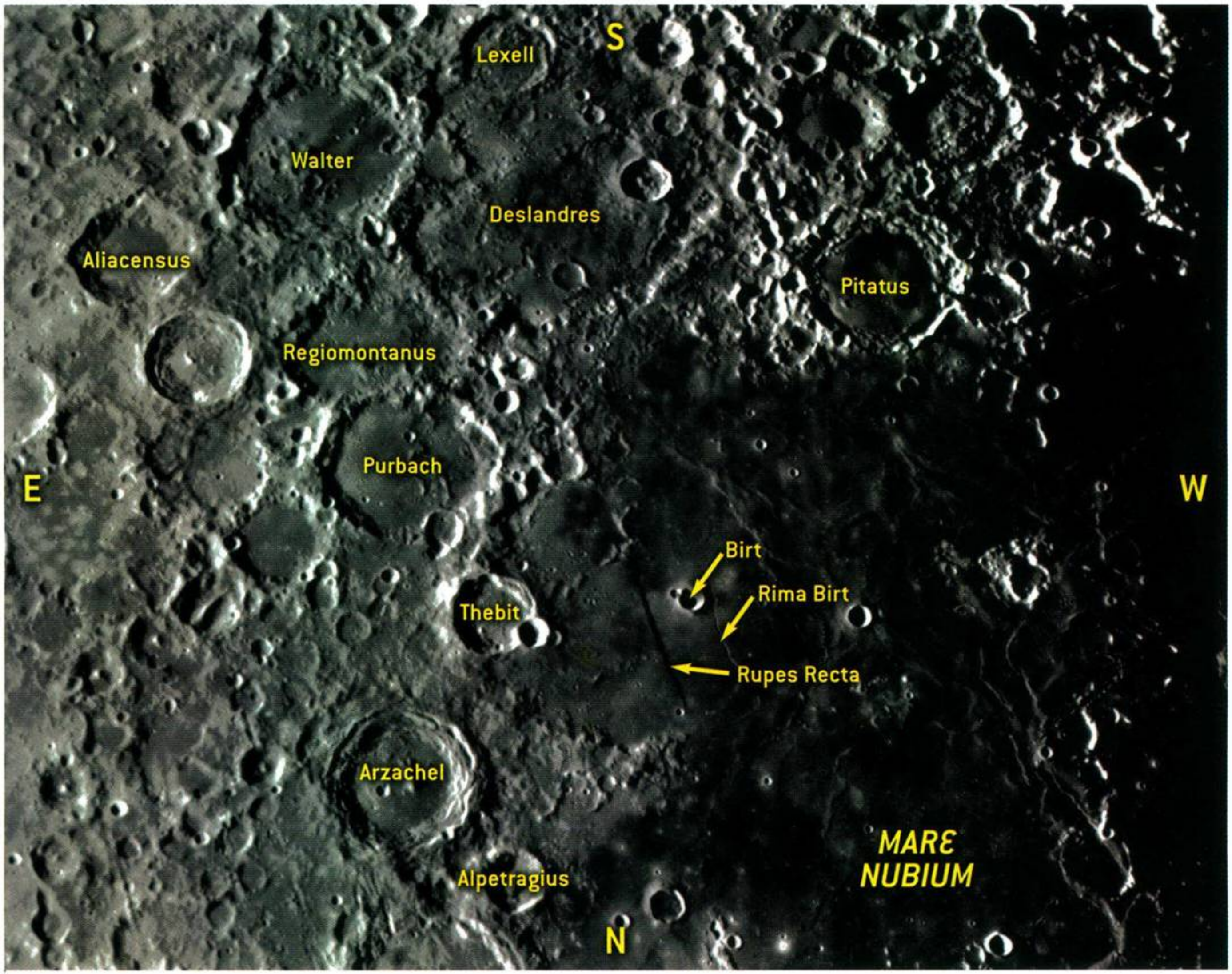
**THE STRAIGHT WALL** lies in Mare Nubium, bordering the highlands. This image is "naked eye," with north at the top. LICK OBSERVATORY

Southeast of Pitatus lies a large, heavily battered crater 115 miles in diameter. **Deslandres** is ancient and has suffered many impacts as well as some resurfacing. On its bumpy floor, look for a line of craterlets running from the northeast to the southwest. Some lunar geologists think these craterlets formed by secondary impacts of ejecta from Tycho, the hub of the Moon's greatest ray system. Tycho lies 220 miles southwest of Deslandres, not far away in lunar terms.

**Lexell**, a crater 39 miles across, somewhat resembles Pitatus because its rim is also partly obliterated. But where Pitatus is filled with dark mare, Lexell is mantled by light-colored impact ejecta from the Imbrium basin, whose rim lies about 900 miles to the north. The same light-colored material sprawls across and pools on the floors of many of the large, old impact craters by the Wall, such as **Walter** (90 miles in diameter), **Aliacensus** (50 miles), **Regiomontanus** (70 miles), and **Purbach** (75 miles).

But more Imbrian effects exist here than just randomly deposited patches of ejecta. If you examine the rims of some of the craters in this area and study their surroundings, you often find faint linear gouges that point back toward Mare Imbrium, one of the Moon's most prominent features.

Debris blasted outward by the impact that formed the Imbrium basin carved these gouges. Huge pieces of rock shot from the impact site on low trajectories and raked the landscape. Then, perhaps only a few minutes later, a slower-moving debris cloud settled over the region like a thick, patchy blanket. Some of the smaller circular craters also may record impacts of high-



**MARE NUBIUM,** shown here with south at the top (the view through most telescopes), is a varied terrain. This is plate F 14 from the Consolidated Lunar Atlas. LUNAR AND PLANETARY LABORATORY

flung debris that rained down from the Imbrium strike. The linear gouges are easiest to see in the northeastern part of the image; a low Sun (rising or setting) reveals them best.

Northeast of Thebit, 60-mile-wide **Arzachel** displays a full range of features. Arzachel was formed by meteorite impact — look just outside the crater for faint traces of its hummocky ejecta halo. It also has a complex central peak and slumped wall terraces. The southern part of its floor is blanketed by Imbrium ejecta, while the northern part shows signs of mare flooding. Finally, a few small, recent meteorite impacts pock its surface.

---

**Robert Burnham** *is the author of* Exploring the Starry Sky *(Cambridge University Press). He is currently working on another book,* The Moon: a Telescopic Guide.

Arzachel's neighbor to the northwest, **Alpetragius**, a crater 25 miles in diameter, wins the award for the crater having the largest central peak relative to diameter. The origin of this massive central peak is unknown. The meteorite that made the crater may have hit a soft spot near the mare that rebounded especially high, or perhaps the impact triggered a dome-making volcanic eruption.

Mare Nubium, the quiet background for this scene, does not fill an obvious, circular basin like Mare Imbrium and Mare Humorum. However, if you insert the correct eyepiece for a low-power view, you'll note that Mare Nubium has curved edges, which hint the sea was formed through a series of impacts. Lunar geologists have studied this area carefully and identified faint traces of partially overlapping small impact basins in this region.

## /// BEST DATES TO OBSERVE

Lunar sunrise and sunset are the best times to view the Moon because shadow detail is greatest then. The best dates to observe the region of the Straight Wall for the next three months are listed below.

**Lunar sunrise**

Oct. 3-5, Nov. 2-4, Dec. 1-3

**Lunar sunset**

Oct. 17-18, Nov. 16-17, Dec. 15-16

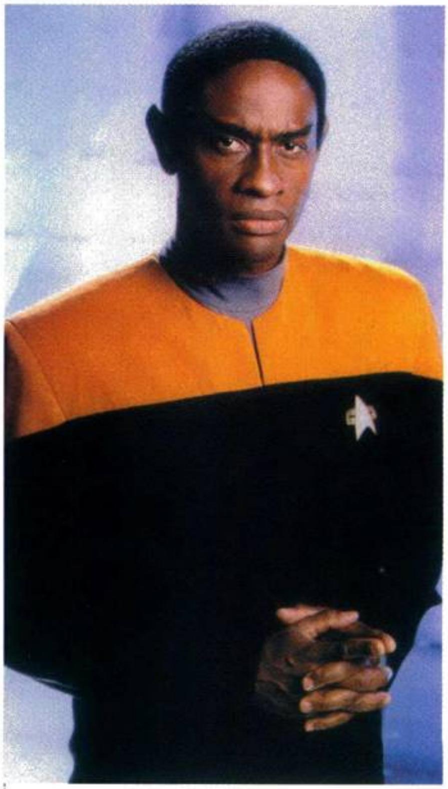
Hundreds of miles northwest of Mare Nubium lies an area rich in radioactive elements. When volcanoes erupted there, lava flowed into the surrounding lowlands. Thanks to the high rate of geothermal heating caused by the radioactivity, a great amount of lava was deposited. ◼

## AMATEUR ASTRONOMY

Skygazing is no longer just for geeks. Now film, television, sports, and rock stars are getting in on the action. /// BY SUSAN KARLIN

# Stars on the stars

Long before he played a space alien on television, Tim Russ had his eyes on the stars. On New Moon nights, he'd drive away from the Los Angeles lights, 90 minutes up Route 5 toward Mount Pinos State Park — his Edmund Scientific 4-inch Astroscan telescope in tow — in search of the best sky viewing.



**TIM RUSS** was an active amateur astronomer long before he became Tactical/Security Officer Tuvok on the popular television series *Star Trek Voyager*. PARAMOUNT PICTURES

"I was into astronomy before I became a Vulcan," laughs Russ, who played Lt. Commander Tuvok on *Star Trek: Voyager* and belongs to three L.A. astronomy clubs. "Sometimes I'll get recognized. Most of the time, amateur astronomers are *Star Trek* fans, but they're not rabid."

When stars discuss the stars, the human kind takes a back seat to those in the sky. "It's a solitary kind of hobby, a kind of Zen experience," says Russ. "When you meet other astronomers, you don't see their faces. You're all there to search and appreciate how massive and far away it all is. From there, your imagination takes over."

Not to mention your bank account, which is why it helps to be on a successful series. Russ uses different equipment for different types of viewing: an 8-inch Meade LX200 GPS telescope with a manual Pentax camera for photos of planets and globular clusters; a digital camera hookup to display images on a laptop computer; a 10-inch Meade Dobsonian telescope for viewing deep-sky objects; and an 85mm Tele Vue refractor with a binocular eyepiece adapter for wide-field viewing.

Russ is part of a growing number of celebrity stargazers — a club that reportedly includes Johnny Carson, David Letterman, Leonard Nimoy, Jimmy Buffett, former Queen guitarist Brian May, and golf champ Phil Mickelson. Confirmed members of the club include former Earth, Wind & Fire guitarist Sheldon Reynolds, former Minnesota Vikings running back Robert Smith, *NYPD Blue*'s Gordon Clapp, and *The Dead Zone*'s Chris Bruno. Russ, Reynolds, and Smith have several decades of combined amateur astronomy and astrophotography experience. Clapp and Bruno, however, have returned recently to a long-lost love of the subject. Russ, Reynolds, and Clapp became smitten with their first telescopes as kids, while Smith and Bruno cut their teeth in college physics and astronomy courses.

However they got there, all are drawn to the hobby's meditative effects. To them, stargazing calms their stressful lives, fuels their sense of wonder, and offers a perspective on Hollywood hubris. "You only think you're important until you look up," says Clapp. "Then you know who's boss."

### Altitude adjustment

As a child, Sheldon Reynolds dreamed of being an astronaut. When he realized a fear of heights could prove a damper in leaving Earth, he opted for rock star over rocket man. Today, he's a member of several Seattle astronomy organizations and an active astrophotographer. His instruments of choice are a Canon A2E, Nikon 990, or Minolta 35mm camera body fitted to a Meade 10-inch LX200 — a birthday surprise from his wife two years ago. Friendships with professional astrophotographers have kept him humble, but trial and error and "a lot of film waste" has netted him some decent Moon, Jupiter, and Comet Hale-Bopp shots. "I cried the night Comet Shoemaker-Levy 9 hit Jupiter [in 1994]," he says. "They showed it on CNN, and I ran outside and saw it firsthand."

More recently, he's become a SETI-enthusiast, visiting the Arecibo Observatory in Puerto Rico with SETI researchers. (He allayed his fear of heights just long enough to ascend the telescope.)

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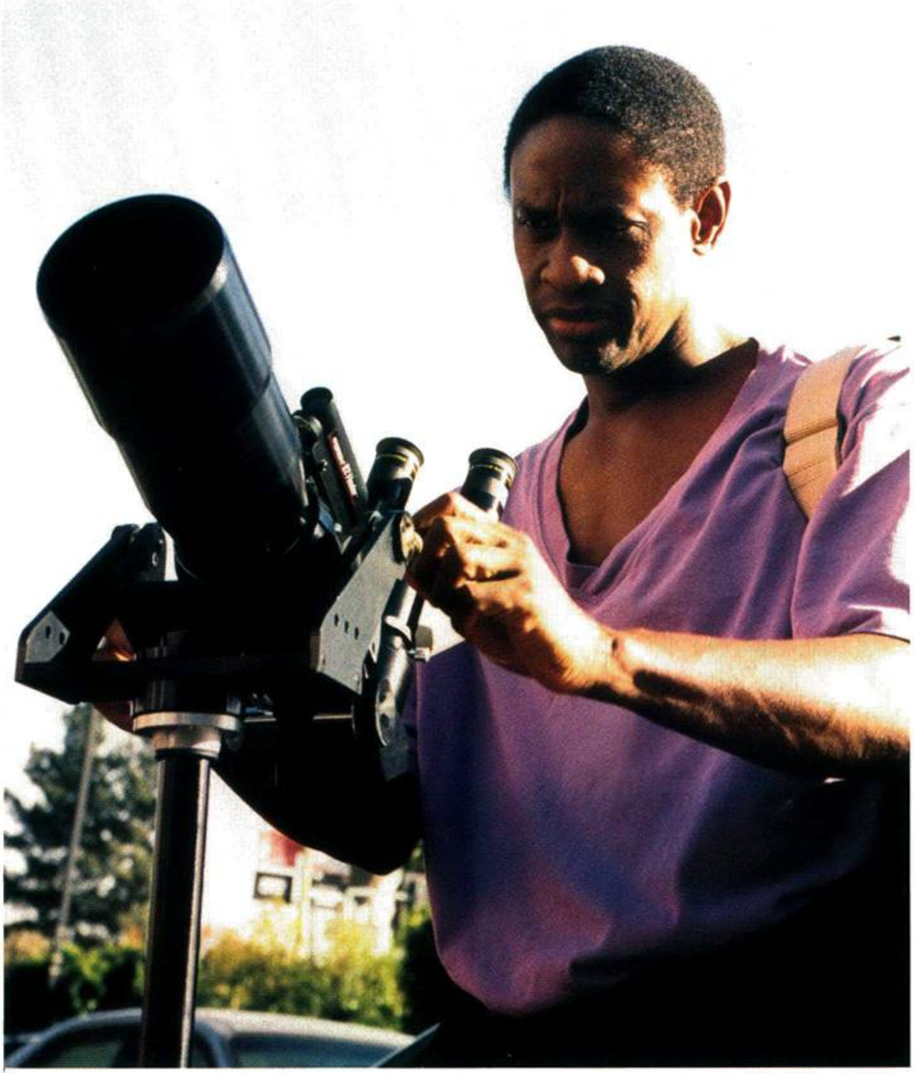
**Susan Karlin** *is an award-winning journalist in Los Angeles who writes about science, technology, and people in the entertainment field. She has contributed to* Discover, The New York Times, Forbes, *and* IEEE's Spectrum.



**TIM RUSS** makes some final adjustments to his Tele Vue 85mm refractor. He has equipped it with a bino-viewer for wide-field views of the Milky Way. JEDDA ROSKILLY

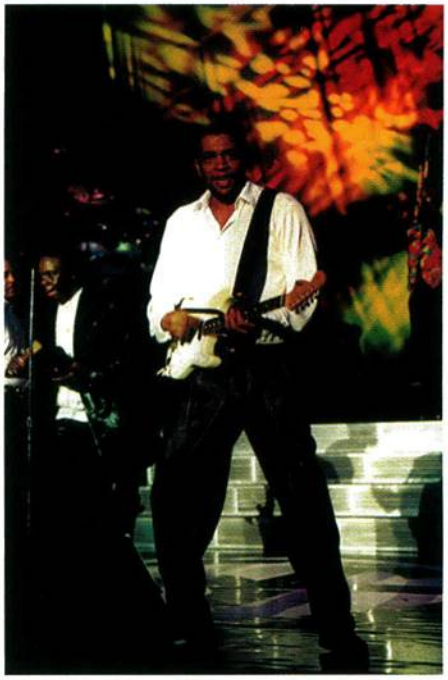
"I'm planning to do a special project to bring awareness to astronomical causes," says Reynolds. "I am so fascinated by the prospects for life on Europa, Mars, or elsewhere in our solar system. I hope we are the generation that gets that confirmation. Maybe if we make contact, it will humble us to be more caring to each other."

## Star jock

Robert Smith plunged into observing during his rookie year with the Vikings in 1993. Prior to that, he had studied astronomy at Ohio State University. While on a fishing trip, he found himself staring at the Moon and suddenly realized, "Hey, I can afford a telescope now! That evening, I went to a small mall and bought a 90mm refractor," he says.

Today, he sports a 4.7-inch Orion refractor and indulges his obsession with cosmology and theoretical physics through copious reading. He also has run children's astronomy seminars and even taken up total eclipse chasing. Returning from Australia where he viewed last December's solar eclipse, Smith immediately began planning a trip to Antarctica in November to view another.

Back in his football days, his enthusiasm won over even his hardened jock teammates. "They knew me well enough to know it's the way I am," says Smith. "I had my telescope at training camp the night Shoemaker-Levy 9 collided with Jupiter. You could see the dark marks that resulted from the impact. Anyone who looks through a telescope for the first time has the same stunned reaction. It's amazing to see light that has left an object so long ago that by the time you're viewing it, it might not be there anymore."

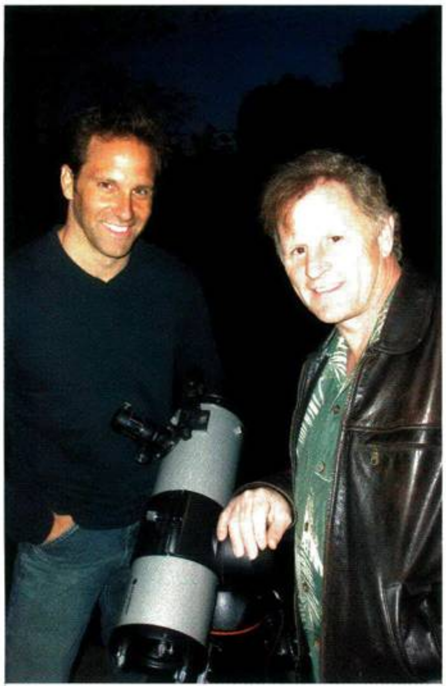


**SHELDON REYNOLDS** has entertained millions of fans worldwide as guitarist for Earth, Wind & Fire. In his spare time, Reynolds enjoys observing and solar system photography. JANIE HENDRIX

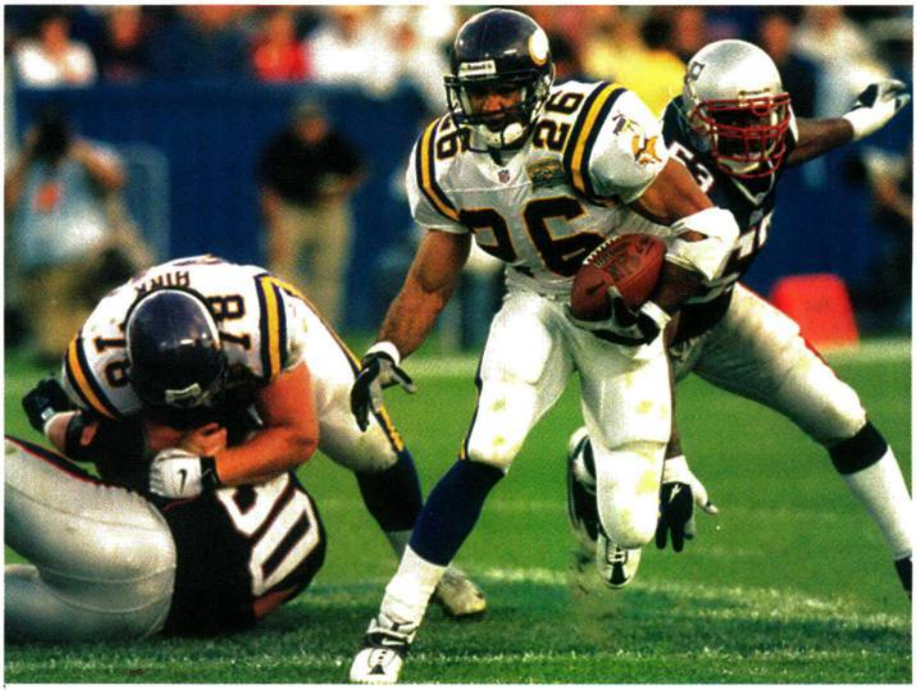
**JUPITER'S CLOUD BANDS** are revealed by Sheldon Reynolds. For this shot, he used a Meade 10-inch LX200, which was a surprise birthday gift from his wife. SHELDON REYNOLDS

**THE MOON** is one of the astronomical targets Sheldon Reynolds likes best. This picture, which he took in 1997, is his favorite. SHELDON REYNOLDS

**CHRIS BRUNO AND GORDON CLAPP** (left and right, respectively) are stars ready for the stars. For celestial viewing, Clapp uses a 4.5-inch Celestron NexStar 114 GT, while Bruno typically uses an 8-inch Celestron G-8N. Both telescopes are Newtonian reflectors. SUSAN KARLIN



**THESE TWO STARS** are serious about their observing. *NYPD Blue*'s Gordon Clapp [right] and *The Dead Zone*'s Chris Bruno are on the roof of Clapp's house using his Celestron NexStar 114 GT. SUSAN KARLIN



**ROBERT SMITH** holds Vikings' team records for rushing yards in a single season and career rushing yards. He is also an avid amateur astronomer. MINNESOTA VIKINGS

## Cosmic coincidence

Gordon Clapp, who won an Emmy for his role as Detective Greg Medavoy on ABC's *NYPD Blue*, has a knack for being in the right place at the right time, astronomically speaking. He witnessed the 1979 total solar eclipse in Winnipeg, Canada, where he was performing in a play, and he saw a beautiful auroral display in New Hampshire. He just happened to be 90 minutes away from the lights of L.A. on the night of the 2001 Leonid Meteor Shower and was able to clock more than 300 meteors in 90 minutes. But it wasn't until his son gave him a 4.5-inch Celestron NexStar 114 GT for his birthday that he ramped up his stargazing.

"The cosmic distance and time scales, along with the sheer number of stars, give me an extraordinary sense of insignificance, while at the same time providing hope," says Clapp. "Insignificance — in being something so small by comparison to something so vast. And hope — in that it makes me feel there's got to be some kind of life beyond ours."

Now, he carts his telescope alongside his golf clubs on road trips. "It's so hard to see in the city, I have to cram all my stargazing into short bursts," he says. "Last winter, I was in Borrego Springs, a desert resort about four hours southeast of L.A. A group of us were outside for three hours, absolutely shivering in the cold, saying to each other, 'Ok, we'll look at just one more open cluster, then we'll go inside.' Before we knew it, another hour went by and we couldn't feel our toes. It was absolutely addicting."

"I took more astronomy classes and got to use the school's telescope. One of my earliest memories was seeing the rings of Saturn." – Chris Bruno

## In search of . . .

Once Chris Bruno landed his role as sheriff Walt Bannerman on USA's *The Dead Zone* last year, he looked for a hobby that both used his mind and was kinder to his body than sports. By coincidence, one of the show's production assistants was an amateur astronomer with a large telescope. For Bruno, this sparked a renewed interest in astronomy and prompted a telescope from his family for Christmas.

"In high school, I took an astronomy class led by a teacher who was really passionate about the subject," says Bruno, also a veteran of several northern lights shows. "My friends and I thought it was the coolest thing. After class let out, we'd get stoned, contemplate the magnitude of the universe, and it would blow our minds. In college, I took more astronomy classes and got to use the school's telescope. One of my earliest and most impressive memories was seeing the rings of Saturn."

Now, Bruno turns his attention to deeper space. "I'm mostly into nebulae," he says. "The great thing about *The Dead Zone* is that it shoots in Vancouver. The light pollution is much less up there, so they have this incredible night sky that we don't get in Los Angeles."

Compared to other groups, you'll probably never see a huge ratio of celebrities staking out a dark patch of sky. "The entertainment industry tends to force your focus inward, on yourself," says Clapp. "To most stars, a mirror is for one purpose — and it's not being at the bottom of a reflecting telescope." ▪

## EQUIPMENT REVIEW

The DGM Optics OA-3.6ATS off-axis reflector brings amateur astronomers the contrast of a refractor coupled with the color clarity of a reflector. /// BY PHIL HARRINGTON

# Off-axis vision

Want to trigger a debate at your next club meeting or star party? Drop this seemingly innocent question on your favorite star gazers: "Which is better: a refractor, reflector, or catadioptric telescope?" Then, as fans of each arm themselves with statistics, preferences, tradition, and their own personal idiosyncrasies, disarm them with this: I know a reasonably priced telescope that combines the high contrast of refractors with the true-color views of reflectors.

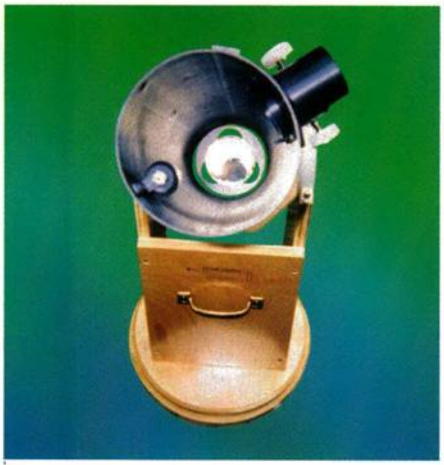
As they settle down, remind them of the pros and cons of each design (see "Name that telescope," page 84). Refractor lovers must cope with chromatic aberration in all but the most expensive apochromatic instruments, and for reflectors and catadioptrics, contrast is their weakness.

Now that your friends are moonstruck, tell them about Dan McShane, an amateur astronomer and telescope maker from Westminster, Massachusetts, who founded DGM Optics in 1996 and began offering clear-aperture reflecting telescopes.

### Hidden mirrors

Outwardly, McShane's design looks just like a conventional Newtonian reflector. But a peek into the tube reveals a difference. Where's the secondary mirror? Look closely. DGM mounts its flat secondary mirror not centrally, but off-axis.

The secret to this strange geometry is the primary mirror. It looks conventional, but it's not. If you slice a traditional primary in half, you find the low point of its curve exactly in the center. The DGM off-axis instruments, however, are "off-center," or more correctly, off-axis. Hard to picture? Imagine taking a standard primary mirror and cutting out three or four small, round sections near the rim. As you can guess, one edge of each small mirror would be higher than the opposite edge.



**THE FRONT VIEW** of the DGM OA-3.6ATS shows the off-axis nature of the secondary mirror, seen on the left edge of the tube. DANIEL G. MCSHANE

**Phil Harrington** *is always on the lookout for new and better telescopes. You can purchase his new observing guidebook,* Star Watch, *at bookstores everywhere or from www.philharrington.net.*

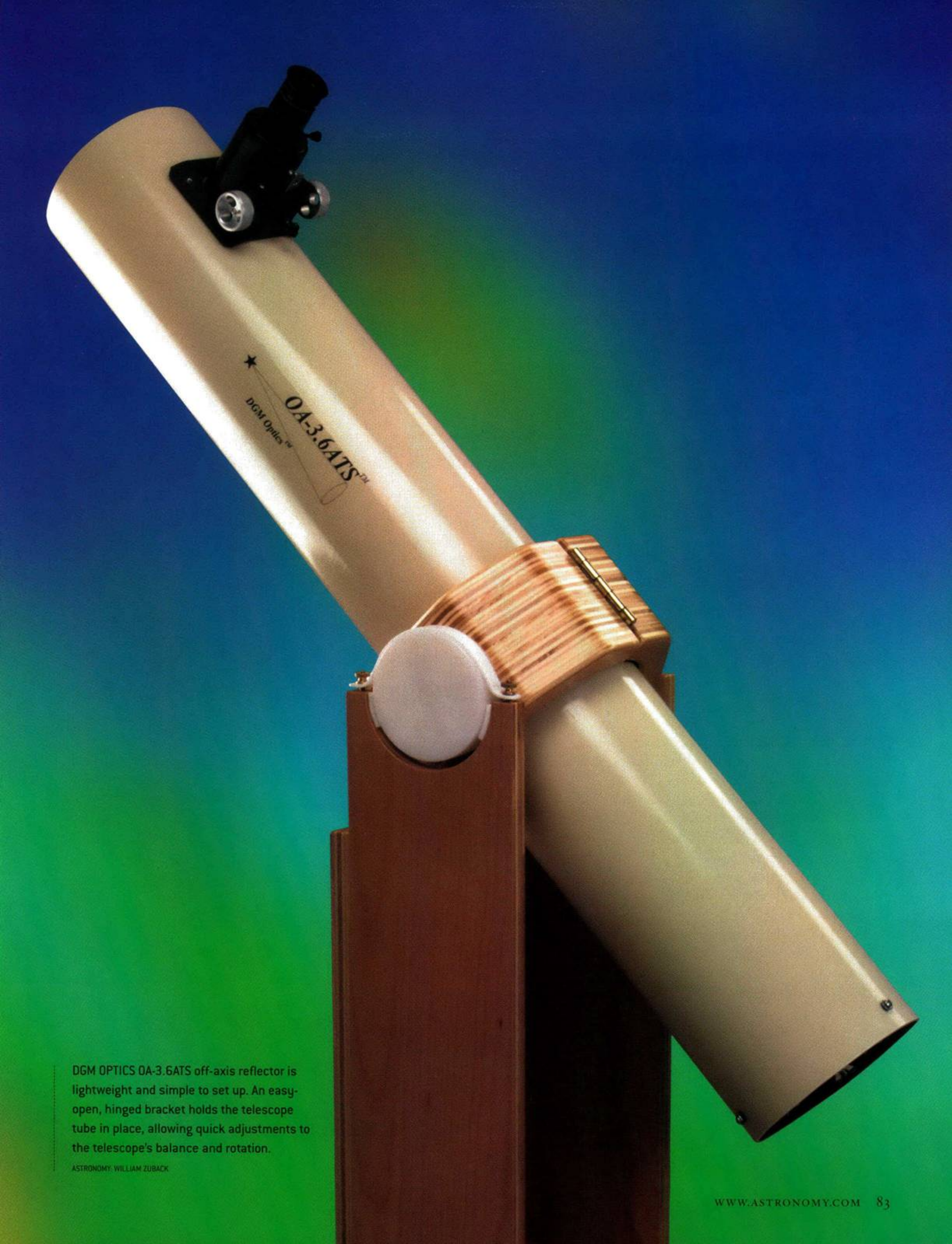
All DGM's off-axis mirrors, manufactured by Dodgen Optical of Flagstaff, Arizona, begin as large, on-axis concave paraboloids. Dodgen produces large "parent" mirrors that DGM sections to produce its off-axis paraboloids. As McShane explains, "The parent must be high quality and free of irregularities because it will have a greater negative impact on image quality than with a conventional mirror."

The performance of a reflecting telescope also depends on mirror coatings. As light reflects off a mirror, some light is lost. Special coatings, called "enhanced," increase reflectivity from the standard 89% to 96%. But nothing in life is free. Coated mirrors generally have a shorter life expectancy than uncoated ones. This coating also may be harder to strip off when realuminizing time comes. Balancing the pros and cons of special coatings, DGM enhances its secondary mirrors but not its primary mirrors.

### The test subject

For this review, DGM supplied their smallest instrument, the OA-3.6ATS, a 3.6-inch f/11.1 reflector. The optical tube assembly (OTA) measures 40 inches from tip to tip and is built around a white PVC tube. Paying a bit more gets you an aluminum tube, and on some of the larger DGM instruments, a lightweight carbon-fiber tube. The OA-3.6ATS features a 2" RCF-1 Crayford focuser from Jim's Mobile, Inc. (JMI), but owners must supply their own finder scopes and eyepieces.

Each DGM instrument may be purchased as an OTA alone or on a furniture-quality Dobsonian mount crafted from 5-ply Atlantic birch plywood triple-coated with clear polyurethane. Mount bearings are Ultra-High Molecular Weight (UHMW) Polyethylene and ride smoothly on Teflon pads. Realizing that a small Dobsonian mount can rock, McShane wisely places three short diagonal legs, also made of UHMW Polyethylene, under the ground board. Together, the telescope and mount assembly weighs 25 pounds; the assembly can be carried by gripping the handle on the front of the mount's rocker box with one hand while placing the other hand under the mount's base. Construction quality of the OA-3.6ATS's tube assembly and wooden Dobsonian mount ranks with the best on the market.



DGM OPTICS OA-3.6ATS off-axis reflector is lightweight and simple to set up. An easy-open, hinged bracket holds the telescope tube in place, allowing quick adjustments to the telescope's balance and rotation.

ASTRONOMY: WILLIAM ZUBACK

## Construction time

The OA-3.6ATS arrived in two boxes; one contained the tube and optics, and the other the pre-assembled Dobsonian rocker box and ground board. Good packing kept the secondary in alignment. Installing the primary mirror and cell was simple thanks to a well written instruction book.

A hinged, birch plywood cradle with an adjustable latch joins the individual pieces of the DGM optical tube assembly. The hinged cradle lets the observer both slide the tube fore and aft for perfect balance as well as rotate the tube to position the focuser at a convenient angle.

Finally, a Teflon strap clamps over an altitude bearing to secure the telescope to the mount. Tightening the strap controls how freely the telescope moves in altitude.

## Optical alignment

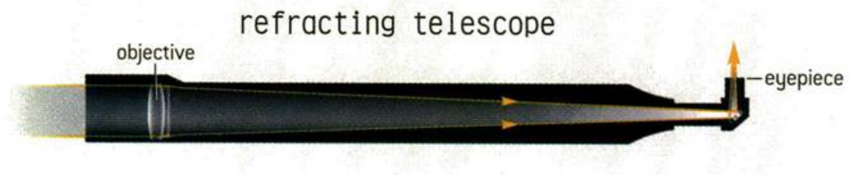
Many multiple-mirror off-axis reflectors are difficult to collimate. But the simpler design of the OA-3.6ATS made it easy to collimate, and the manufacturer's instructions guided me through the process.

The first step, adjusting the secondary mirror, proved unnecessary as the mirror arrived in perfect alignment. If necessary, the mirror can be moved back and forth and left and right. Its holder does not have conventional adjustment screws but moves as a unit instead.

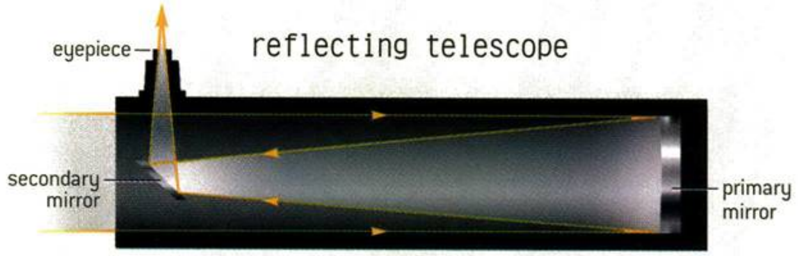
Primary mirror collimation for the OA-3.6ATS is similar to a standard Newtonian telescope. Aim the telescope toward a

## /// NAME THAT TELESCOPE

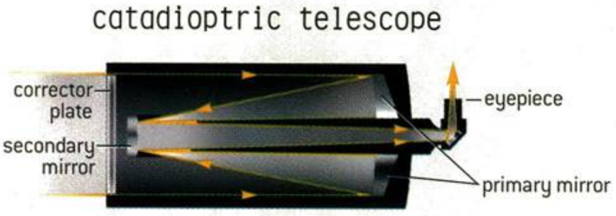
**REFRACTING TELESCOPES** focus light through two or more lenses. This straight-through view of the sky offers excellent contrast. Lenses, however, bend some colors more than others, creating chromatic aberration — a misalignment of the colors of an object. Apochromatic refractors use combinations of lenses to focus all colors as closely together as possible. This added clarity, however, adds to the price.



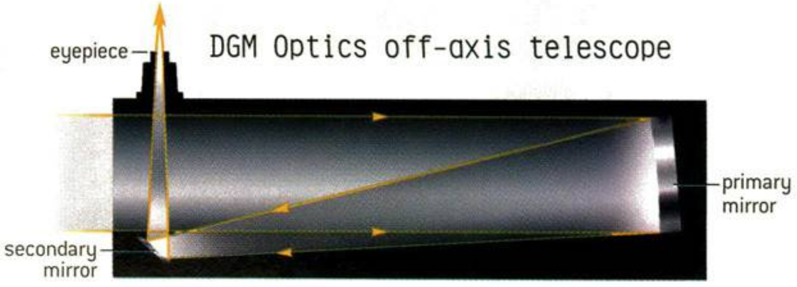
**REFLECTING TELESCOPES,** such as Newtonians (the design found on virtually all Dobsonian mounts), use mirrors to gather and focus light. A "primary" mirror found at the teleschope's base collects the light, which is then bent out of the tube and into an eyepiece by a "secondary" mirror. This mirror is suspended on a structure called a "spider." The secondary mirror and spider obstruct part of the tube, decreasing the amount of light hitting the mirror — decreasing image contrast.



**CATADIOPTRIC TELESCOPES,** sometimes called compound telescopes, use both lenses and mirrors to focus light. Two popular catadioptric telescopes are the Schmidt-Cassegrain and Maksutov-Cassegrain designs. These instruments collect light through a corrector lens and onto a primary mirror. The light reflects to a secondary mirror and into a detector (eye, camera, or CCD). Like a reflector, these systems often have reduced contrast.



**THE DGM OPTICS OFF-AXIS DESIGN** differs from a Newtonian reflector by the shape of the primary mirror and the location of the secondary mirror. DGM's off-axis telescope uses an asymmetric mirror to send light to a secondary that hides on the side of the telescope's tube. From this location, the secondary blocks no light, giving the telescope the contrast of a refractor, while possessing the clarity of a reflector.



white background and look through the focuser without an eyepiece. Move your eye toward the front edge of the focuser — toward the front of the telescope tube. The barest sliver of the secondary should reflect onto the edge of the primary mirror. Adjust the primary's aim by turning three spring-loaded screws on the back of the mirror cell one at a time. Initial collimation is complete when the reflected sliver of the secondary lies along an imaginary line running the length of the tube from the secondary mirror to the primary.

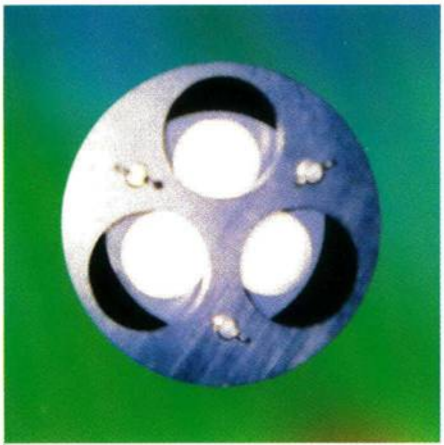
As a final check of collimation, center a star in a medium-power eyepiece and slightly de-focus the image. If the unfocused ball of starlight looks oval, move the telescope around until the star is perfectly round. Then, using the three screws on the back of the mirror cell, adjust the mirror's tilt to bring the round star ball back to center of the field of view.

## Looking skyward

With the optics fully adapted to the chill of the winter night, I aimed the OA-3.6ATS toward several moderately bright stars. Each showed a well defined Airy disk surrounded by a single diffraction ring — exactly what should be seen through an unobstructed telescope with good optics. Star testing further proved the instrument's quality. I saw nearly identical diffraction disks on either side of focus, only the slightest hint of spherical aberration, and no signs of astigmatism.

The Moon was stunning through the OA-3.6ATS. Some of my favorite lunar attractions — the craters Copernicus, Clavius, Plato, as well as the Straight Wall, and several major mountain ranges — were so sharp I felt I was almost in lunar orbit. Saturn, riding high in the western evening sky, was my next target. Again, the OA-3.6ATS provided striking image contrast and sharpness from the outset. At 145x, the Cassini Division looked as though drawn by a sharp pencil, and the subtle shading difference between Saturn's whitish equatorial region and beige temperate zone was conspicuous.

I traveled 1,500 light-years for my next target, the Orion Nebula (M42). A 3.6-inch aperture — even with excellent optics — shows only so much of faint, ethereal tendrils, yet the variations within the clouds of the nebula were impressive. Filamentary details around the dark projection called the Fish's Mouth were especially noteworthy at both 145x and at 85x.



**THE MIRROR CELL** of the DGM OA-3.6ATS can be adjusted the same way as any Newtonian telescope. Note the primary mirror is not centered in the tube. DANIEL G. MCSHANE

Next was the binary star Castor in Gemini. The system's two bright stars, currently separated by about 4", were easily resolved at 145x. Beyond that, the OA-3.6ATS showed the pair as two tiny disks of light surrounded by single diffraction rings and separated cleanly by a black gap — a perfect textbook image.

The open cluster M35, also in Gemini, was magnificent. Cluster stars glistened at 46x. From a dark-sky site, the OA-3.6ATS allowed me to make out just a few of the cluster's individual stars, none of which shine brighter than magnitude 12.

I turned to Jupiter high in the eastern sky and saw magnificent contrast in the planet's ribbon-like clouds, along with their delicate swirls and eddies. The Great Red Spot, usually a low-contrast feature through such a small aperture, stood out surprisingly well. Best of all, no hint of false color (chromatic aberration) sneaked through the OA-3.6ATS.

## Technical details

As much as I enjoyed the optical excellence of the DGM scope, its mount wobbled enough to cause difficulty focusing short focal-length eyepieces. During my "rap test" — I bump the side of the tube with my open palm while looking through the eyepiece — images took several seconds to settle back down. Placing anti-vibration pads, such as those sold by Celestron and Orion, under the mount's feet reduced vibration by about a second and is recommended for this scope.

In addition to Dobsonian-mounted instruments, DGM offers OTAs without mounts, giving customers a chance to mate telescopes with mountings of their choice. The OA-3.6ATS would go perfectly on a Vixen Great Polaris, Orion SkyView Pro, or Celestron CG-5 German equatorial mount. Each of these would have the added advantages of slow-motion controls as well as optional clock drives.

DGM off-axis reflectors are great for planet watching and double star observing, but the coarseness of the RCF-1 focuser made attaining a sharp focus difficult. DGM will substitute any focuser, charging the price difference between the RCF-1 and the new unit. I suggest a two-speed focuser such as JMI's DX-1.

These minor complaints shouldn't detract from this well made instrument. The OA-3.6ATS is perfect for anyone who wants apochromatic quality without the high cost. If you are a lunar, planetary, or double star observer who longs for a better telescope but has resisted investing thousands of dollars on a top-notch apo, the DGM OA-3.6ATS is your salvation.

And besides, you'll win the debate. ■

### /// OA-3.6ATS SPECIFICATIONS

**Clear aperture:** 92mm ± 1mm
Focal length: 1020mm ± 2%
**Secondary mirror:** 1.3-inch minor axis elliptical flat
**Primary mirror coating:** Standard aluminizing (89% reflectivity)
**Secondary mirror coating:** Enhanced aluminizing (96% reflectivity)
**Tube length/diameter:** 40 inches long by 6.1 inches wide
**Eyepiece height at zenith:** 42 inches
**Weight of OTA:** PVC tube, 7 pounds; aluminum tube, 6 pounds
**Weight of mount:** 18 pounds
**Price:** PVC tube assembly: $825
PVC OTA only: $675
Aluminum tube assembly: $1025
Aluminum OTA only: $875

**Contact information:**
DGM Optics
P.O. Box 120
Westminster, MA 01473
[t] 978.874.2985
[w] www.dgmoptics.com

Successfully shooting the night sky requires only a camera and a telescope. Learn how to get the most out of your bare-bones setup. /// BY JOHN SHIBLEY

# Simple telescopic shooting

When you flip through the pages of *Astronomy*, do you ever wonder how the pictures were taken? Creating spectacular photographic astroimages can be as easy as holding your camera up to the eyepiece of a telescope pointed at the Moon, or as complicated as taking carefully guided multi-hour exposures with a well-balanced scope.

Generally, the easiest targets to shoot are the brightest. Acceptable images of the Sun (through a solar filter) and the Moon are "quick grabs" through a telescope. Full-disk photos rarely take longer than half a second. Magnified photos might require you to perform a rudimentary polar alignment on a motor-driven scope. You also can "piggyback" your camera on a precisely aligned scope to take wide-field images of the night sky.

Even a novice astrophotographer will achieve outstanding results with knowledge of a few simple tricks. Read on, and take your astrophotography to the next level.

**THE THREE-DAY OLD MOON** flares an angry, illuminated edge while earthshine illuminates the remaining disk. Mansfield Clinnick took this 15-second exposure on April 13, 1994, using a 100mm f/12 refractor and a camera loaded with Kodacolor 400 film.

## First, bright steps

The Moon makes an excellent first target. Its brightness and size make it the perfect subject on which to hone beginning astrophotographic skills. Simply pointed through an eyepiece, cameras can create quality images.

Theoretically, you can hold a camera up to the eyepiece and snap a photo. A tripod, however, will hold a camera steady while you align and focus it. Work quickly or the Moon will drift out of your field of view. You'll need a single-lens-reflex (SLR) camera that allows you to focus the telescope while looking through the camera's viewfinder. Use a 50mm lens focused to infinity and a wide-field, long eye-relief eyepiece.

An economical eyepiece that fits the bill is a 25mm or longer Plössl. Set the camera's speed using the accompanying table. Take multiple shots, bracketing the suggested exposure with shutter speeds two or three settings to either side. Use a cable release to minimize vibrations.

Through-the-eyepiece photography, also called *afocal* photography, is slightly different with a digital camera. It may be possible to attach your camera directly to the eyepiece. Look for eyepieces with threaded eyecups that unscrew, and try threading your digital camera in place of the eyecup. If your camera doesn't immediately match up, accessory vendors such as ScopeTronix (www.scopetronix.com) sell a wide array of adapter rings and brackets for attaching digital cameras to telescope eyepieces.

Set the digital camera's focus to infinity, and focus the telescope looking through the camera's viewfinder. Focus will vary if you employ the camera's zoom. Planetary and magnified lunar photography are easiest with digital cameras. In the days before digital cameras, skyshooters connected a 35mm SLR body to a projection tube on the end of a scope where an eyepiece could project a highly magnified image onto film. Today, hooking a digital camera to an eyepiece works best. The only difference from standard, afocal lunar photography is that you'll want to use slightly higher-power (15mm to 20mm) eyepieces. As an alternative, couple a low-power eyepiece with a Barlow lens. In any case, because the magnification is higher and less light is reaching the film, you'll need to take exposures of several seconds with a motor-driven telescope.

Many motorized alt-azimuth mounted telescopes offer enough accuracy to capture untrailed views with exposures of a few seconds. For short exposures, a motorized equatorial telescope doesn't require elaborate polar alignment. Just point the scope's polar axis at Polaris. Spending five minutes securing a good alignment is enough to take magnified, several-second exposures without noticeable trailing.

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**John Shibley** *straddles the analog and digital universes under the dark skies of Michigan's upper peninsula.*

One trick digital astrophotographers use on magnified lunar and planetary — and sometimes even solar — images is called "image stacking." Take a sequence of short-exposure images of the same object, then use computer software to combine the best of them. This process cancels out the graininess that occurs when there isn't enough signal (light) in an image. It also enhances subtle details and image contrast. AstroStack (www.astrostack.com) provides free downloads of such software.

The Sun also makes an excellent target for afocal photography. Always use a solar filter that fits snugly over the front of the telescope! Follow the same techniques as shooting the Moon.

## Taking off the eyepiece

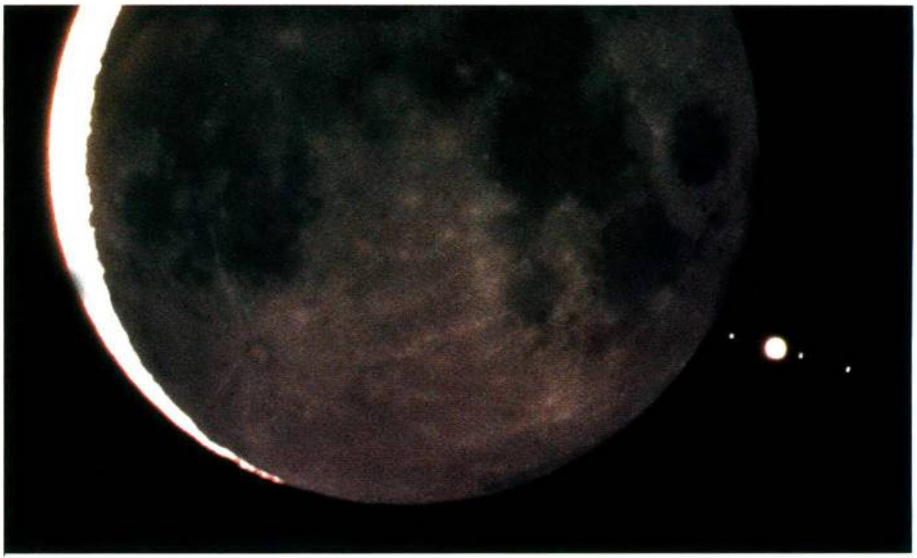
Rather than taking pictures through a telescope's eyepiece, you also can replace the eyepiece with a 35mm camera body, transforming your telescope into a giant telephoto lens. Many astronomical dealers offer adapters — T-rings and T-mounts — to couple the camera body to a telescope's focuser. The T-mount replaces the camera lens, and its T-ring mates the T-mount to the camera.

How big a telephoto lens does a telescope become? Note the focal length and focal ratio (typically listed in the scope owner's manual or on a nameplate mounted to the telescope). Popular 8-inch f/10 Schmidt-Cassegrain telescopes have a focal length of 2000mm. When an SLR camera is mounted to the focuser, the telescope becomes a 2000mm f/10 telephoto lens. This provides a field of view that precisely frames the Moon's disk.

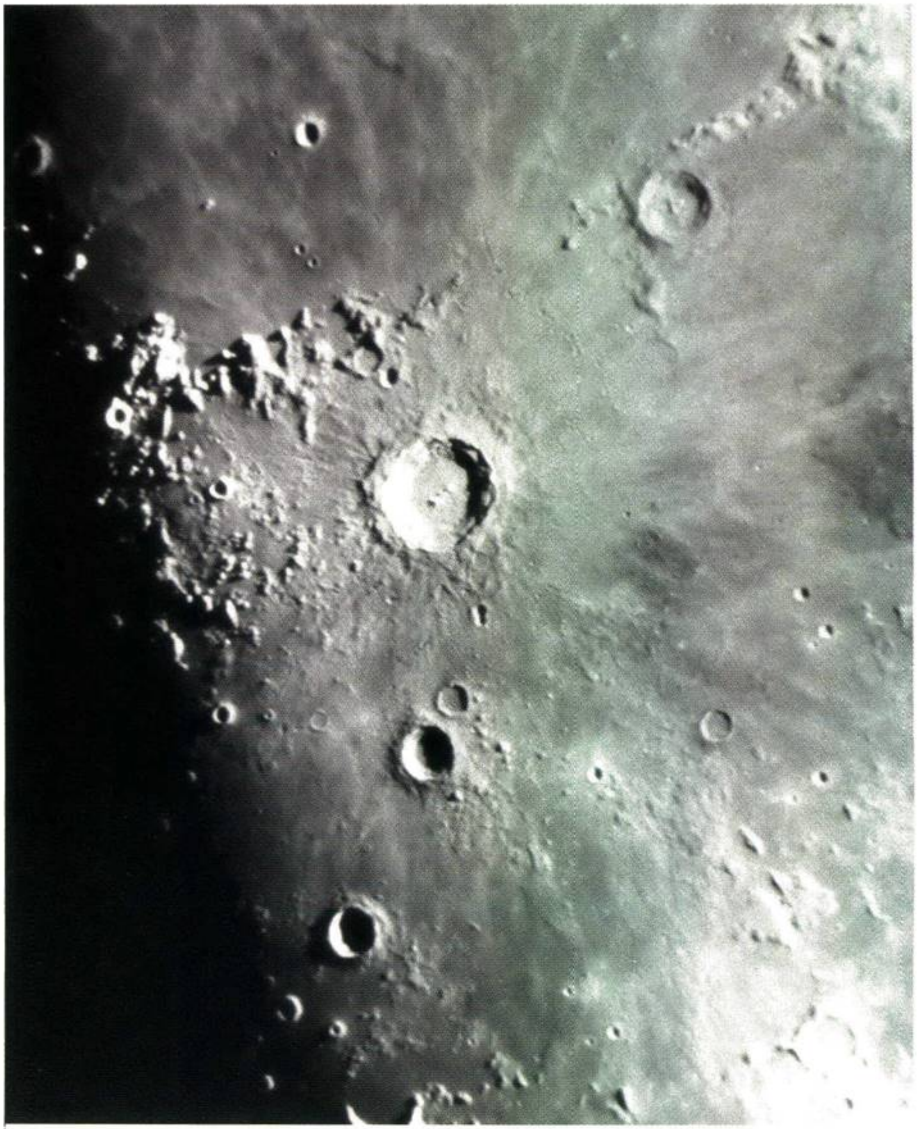
You'll want to vary your shutter speed depending on how much of the Moon is illuminated and what type of film you're using. Slower-speed films (with ISO numbers less than 200) offer finer grain images and better contrast than faster films. Use ISO 400 or faster film and a scope with tracking to capture earthshine — light reflected off Earth's clouds and oceans that faintly illuminates the dark part of the crescent Moon. A fast film is necessary because earthshine, which shows up as a blue-gray glow in images, is quite faint.

## Astrophotography, on-track

Another version of simple telescope photography doesn't use the telescope's optics at all. Long-exposure "piggyback" photog-



**JUPITER TOUCHED THE MOON** on August 18, 1990. Christopher Galfo took this image with a 14-inch Celestron Schmidt-Cassegrain telescope at f/7 using Konica 3200 film.



**CRATERS DIMPLE A DIGITAL LUNAR IMAGE.** John Sussenbach used Registax software to combine 50 frames taken with a Philips ToUcam Pro camera with a 2x Barlow lens on an 11-inch Celestron SCT.

## /// DIGITAL CONSIDERATIONS

Some consumer digital cameras are more astrophotography-friendly than others. Here are a few features to look for when selecting a good digital astro-camera.

**Internal zoom lens.** Camera models with barrels that telescope in and out of the camera body won't work when hooked up to an eyepiece. Look for a camera that has an internal zoom, where elements inside the camera body's lens housing move, rather than the whole lens barrel.

**Optical zoom.** Today's digital cameras come with two types of zoom features. A digital zoom merely crops the image electronically without magnification. An optical zoom actually magnifies the image that strikes a camera's chip; this yields greater resolution.

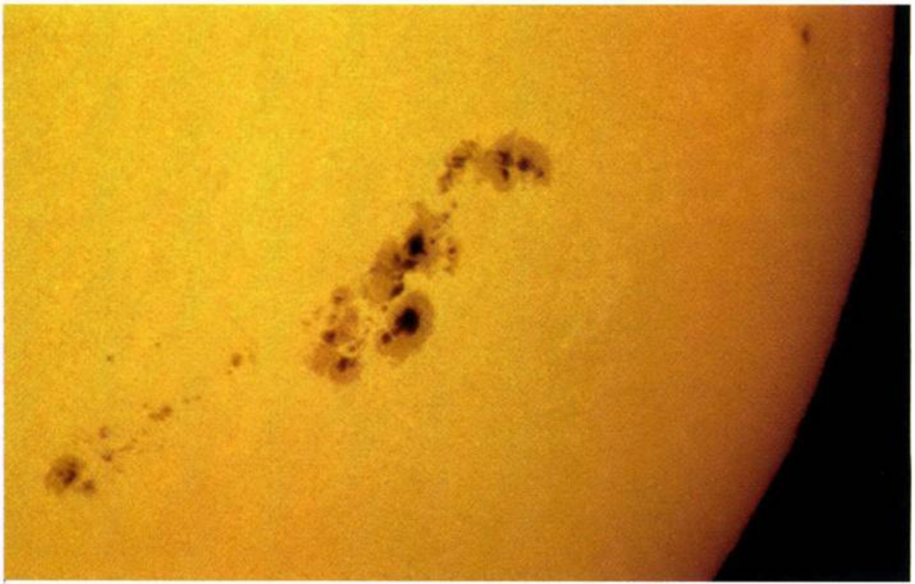
**Exposure override.** Lunar and planetary photography capture very bright targets against the black sky. A dazzling planet in the darkness of space will fool a digital camera's auto-exposure system. Use a camera that lets you adjust its light meter to create over- and underexposures. A camera that lets you manually adjust shutter speeds and lens openings is even better.

**Remote cable.** Some models support a remote firing button to trigger the shutter. This works well when you want to take an exposure without fumbling for the shutter button and jiggling the image.

**Threaded lens.** Look at the camera's front lens. If it's threaded, the camera will readily accept adapters that attach it firmly to many eyepieces. While adapters that connect eyepieces with non-threaded lenses are available from accessory dealers, a threaded mount is the most secure way to attach a camera to a telescope.

**Rotating body.** Trying to view the back display of a camera when the telescope is pointing overhead is awkward. If the camera's main body pivots separately from the lens housing, it will save you some contortions at the telescope.

**Noise reduction.** Everyday digital cameras are optimized for conventional daylight photography. Exposures longer than half a second create grainy, "noisy" images. Look for camera models that automatically process out some of the noise from multi-second exposures.



**SUNSPOTS POX A SOLAR VIEW.** Robert M. Sandy of Roanoke, Virginia, captured this 1/1000-second image using a Nikon 800 digital camera with a 3x teleconverter (equivalent to a 300mm lens) and a red filter. This image was taken on December 14, 2001.

### /// Exposure guide for lunar photography (f/10 telescopes*, time given in seconds)

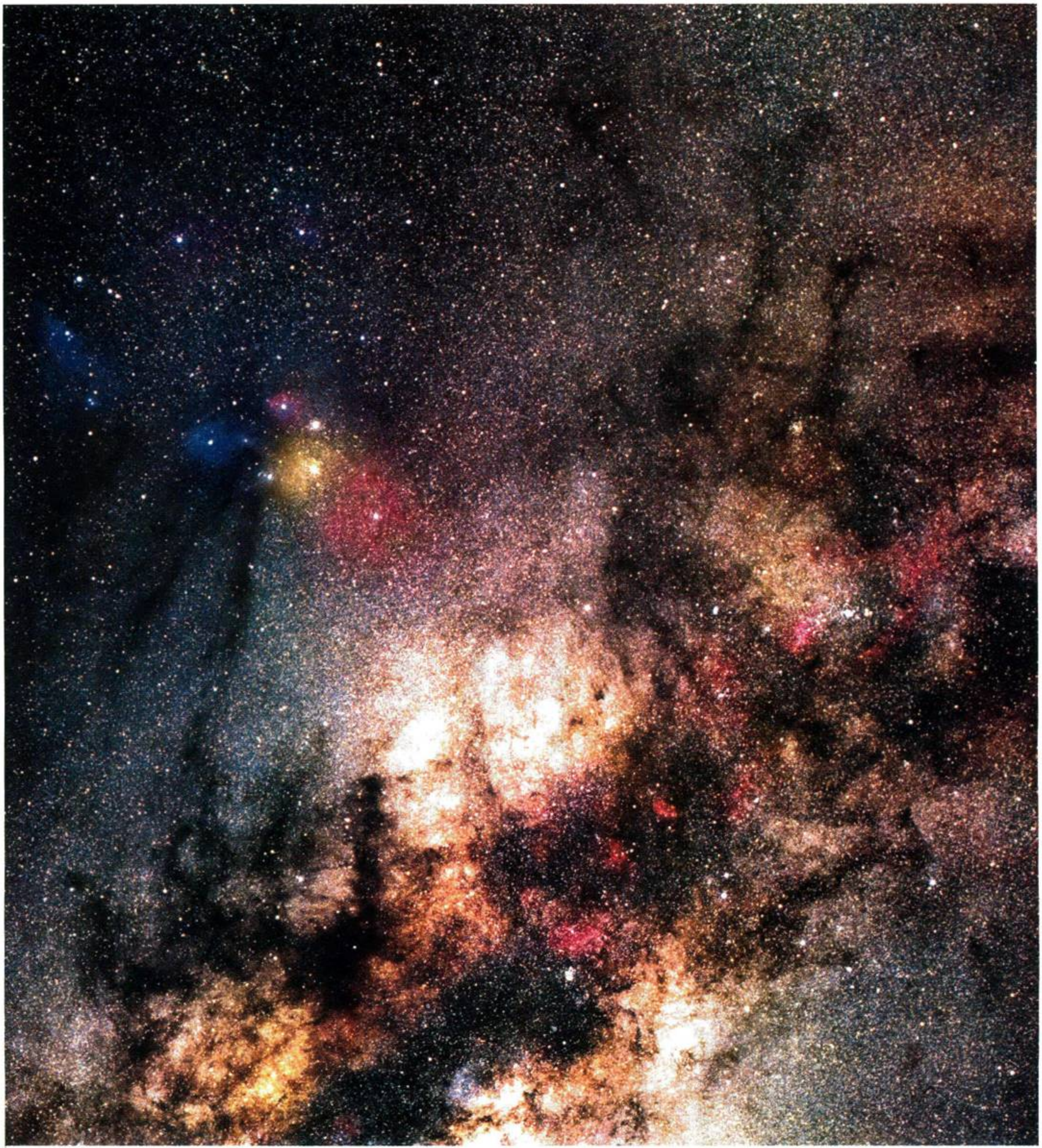
| FILM SPEED | FULL MOON | GIBBOUS | QUARTER | CRESCENT (THICK) | CRESCENT (THIN) | EARTHSHINE |
|---|---|---|---|---|---|---|
| 25 | 1/60 | 1/30 | 1/15 | 1/8 | 1/4 | not recommended |
| 50 | 1/125 | 1/60 | 1/30 | 1/15 | 1/8 | 40 to 80 |
| 100 | 1/250 | 1/125 | 1/60 | 1/30 | 1/15 | 20 to 40 |
| 200 | 1/500 | 1/250 | 1/125 | 1/60 | 1/30 | 10 to 20 |
| 400 | 1/1000 | 1/500 | 1/250 | 1/125 | 1/60 | 5 to 10 |
| 800 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1/125 | 2 to 5 |
| 1600 | 1/4000 | 1/2000 | 1/1000 | 1/500 | 1/250 | 1 to 2 |

*Set the camera's shutter speed one increment slower for f/16 telescopes, and one increment faster for f/8 telescopes. Regardless, hedge your bets by bracketing one or two increments above and below a suggested exposure.

raphy puts motorized equatorial telescopes to work as tracking platforms. You'll want to mount your camera to the telescope with a ball-head adapter. This will allow you to center the camera and telescope on slightly different targets — an important feature when guiding the telescope on a bright object you don't want in the photo. The ideal camera for longer astronomical images can take long "bulb" or "time" exposures without using a battery. It also should accept a cable release.

Where digital cameras have cornered the market for quick lunar and planetary photography, longer exposures are still best with film cameras. The longer a digital exposure, the more electronic noise builds up in the image. Some cameras can filter out the noise in a one-minute exposure, but they usually can't correct longer exposures. CCD cameras designed for astrophotography actually cool their chips to minimize noise.

Film also captures more detail than digital media does. The highest-resolution uncompressed image obtainable with a conventional digital camera is less than 20 megabytes. A typical 35mm frame of film, however, captures upward of 500 megabytes of information. For now, there's no other affordable medium that captures the sky with such fidelity.



**THE MILKY WAY IS BEJEWELED** with star clusters in Ophiuchus. Tony and Daphne Hallas of Foresthill, California, created this 30-minute exposure on April 18, 1999, with a Pentax 90mm lens at f/5.6 using hypered Kodak Professional PPF 400 film.

There are two types of piggyback astrophotography. The first and simplest type is wide-field photography. It merely requires an unattended telescope to track the sky during 20-minute exposures. You'll want to use a 35mm SLR camera loaded with ISO 400 film. Use a wide-angle lens with a focal length between 24mm and 35mm. The lens also should be reasonably fast — capable of opening up to an f/stop number of f/4 or lower.

To take an image with a driven, equatorially-mounted scope that's roughly aligned, focus the camera lens to infinity and lock the shutter open for 10 to 20 minutes. Shoot some pictures with the lens wide open for maximum light grasp, and then take some with the lens stopped down one f/stop for better image quality. A good target for piggyback photography is the Milky Way. You can make your own

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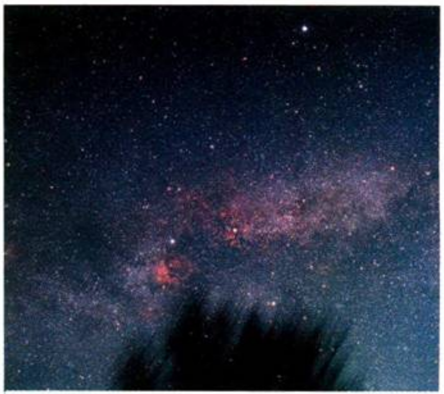

**CYGNUS RISES OVER A SHRUB.** Gianni Tumino and Melania Pluchinotta of Raguso, Italy, took this guided, 20-minute exposure on April 29, 2003, with a Nikon 35mm lens at f/4 using Kodak Ektachrome 200 film pushed to 340 ISO.

deep-sky atlas, too — a 10-minute constellation photo on ISO 1600 film captures stars down to around 13th magnitude.

A second form of piggyback photography uses a 35mm camera fitted with a telephoto lens to capture a smaller, slightly magnified portion of the sky. Try telephoto lenses between 85mm and 300mm at f/4 or faster. To get good images, you'll need to guide the telescope's tracking. This involves centering a reasonably bright star in an eyepiece's field of view and keeping it there during exposures that range between 15 and 40 minutes.

You may want to use an eyepiece specially designed for guiding, one that has lighted, dimmable crosshair reticules built into it. This way, you'll know when the star wanders and in what direction. Some motorized scopes come with a built-in drive corrector and a control paddle. If your mount doesn't come with one, telescope accessory dealers sell drive corrector units for most motorized mounts. Don't feel up to tracking by eye? Several manufacturers now offer CCD-based autoguiders for around $500 that keep equatorial scopes with motor drives on both axes locked on a guide star.

As with all art forms, astrophotography requires a lot of patience. With the skills gained from practicing the techniques outlined above, and with a modest investment in equipment, you'll be ready for the next step: long-exposure photography through your telescope.

But that's grist for another issue. ■

To learn more about astrophotography, visit www.astronomy.com/toc

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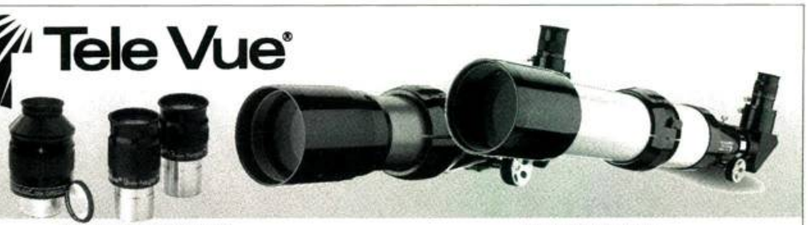

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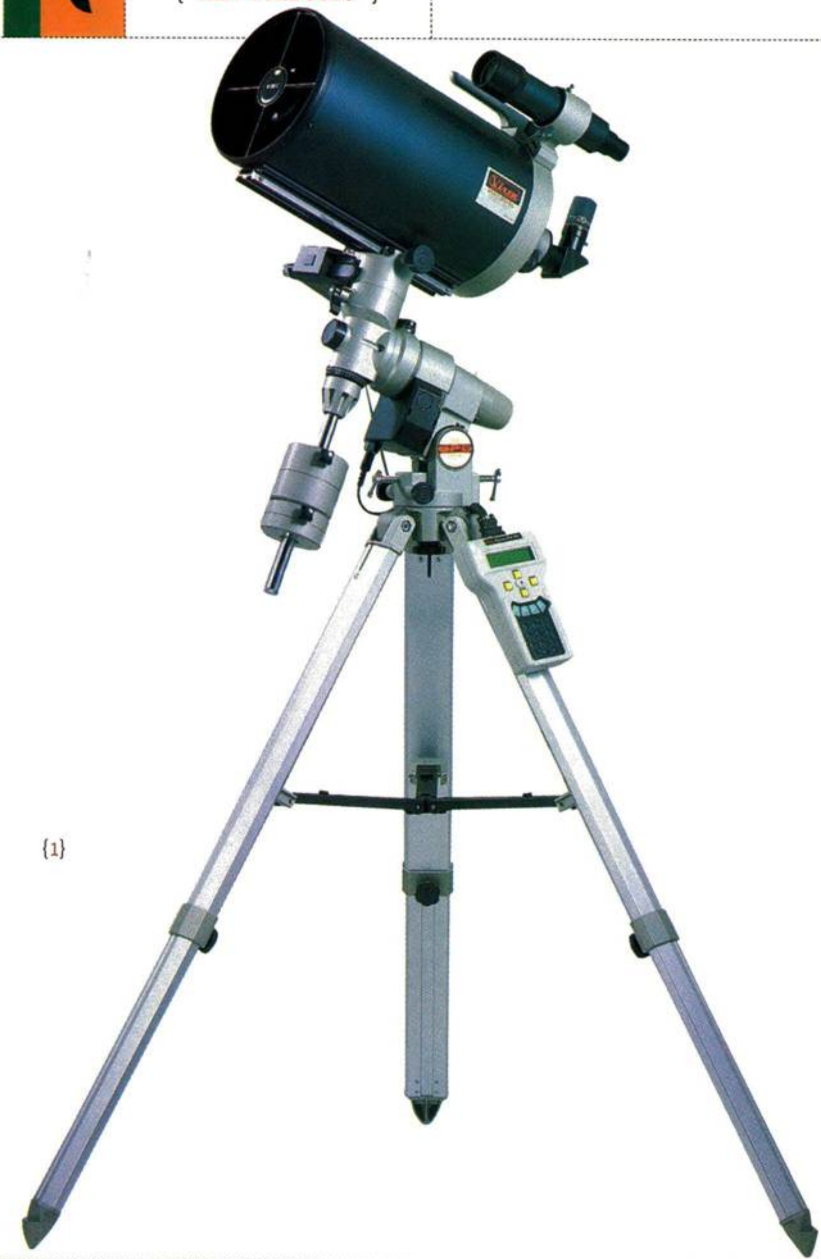

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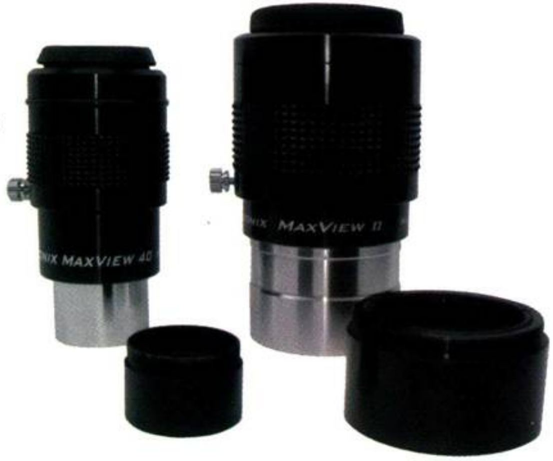

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Touring the Universe
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Ken Graun

### *Meteorites, Ice, and Antarctica: A personal account*

William A. Cassidy, 341 pages, Cambridge University Press, New York, 2003; ISBN 0-5212-5872-3; hardcover, $30.

In 1996, the announcement that a meteorite from Mars might contain traces of ancient life rocked the scientific community and generated a huge media buzz. The controversial meteorite, dubbed ALH 84001, may draw curious readers to geologist William Cassidy's new book.

But *Meteorites, Ice, and Antarctica* is about more than this infamous martian rock that turned up on the Frozen Continent in 1984. It's a fascinating description of how Cassidy's own search for rare extraterrestrial rocks — from Mars, the Moon, and beyond — unfolded.

Cassidy, a geology and planetary science professor at the University of Pittsburgh, was inspired to propose a meteorite-hunting trip to Antarctica after listening to other scientists describe their study of Antarctic space rocks about 30 years ago. After many disappointments trying to get his project funded, Cassidy finally got the green light from the National Science Foundation for an expedition in the 1976–1977 season. That was the beginning of what became the U.S. Antarctic Search for Meteorites (ANSMET), which has been operating ever since.

The first section of the book, "Setting the Stage," recounts this history and gives a complete overview of what is involved in setting up and conducting research in Antarctica's harsh environment. Drawing on years of field experience, Cassidy provides a lucid and often humorous account of daily life in the cold desert, a setting that requires more stringent safety precautions than many other places on Earth.

The second section deals with the project's results. The hype surrounding ALH 84001 may make readers wonder how scientists determine a meteorite's origin. Cassidy describes it as a process of elimination that takes into account measurements of oxygen isotope ratios, mineral composition, and the preferred orientation of igneous minerals (which can indicate the parent body's size), among other factors.

The last section of the book, "Has it been worthwhile?" is an overview of the research that has been done and where future research might lead. Indeed, "worthwhile" is an understatement. Prior to the first discovery of a meteorite in Antarctica, less than 2,000 meteorites had been recovered worldwide. As of today, more than 30,000 Antarctic meteorites have been collected — 11,000 by ANSMET alone.

While the book is intended for the "intellectually curious general reader," portions of it contain an almost overwhelming amount of geological data that many readers will likely skim over. That aside, *Meteorites, Ice, and Antarctica* should be on this year's "must read" list for anyone even peripherally interested in this exciting field of study. — **JOHN E. SCHINDLER** *is a hydrogeologist who received the Antarctica Service Medal of the United States in 1999.*

### *Leaving Earth: Space Stations, Rival Superpowers, and the Quest for Interplanetary Travel*

Robert Zimmerman, 560 pages, Joseph Henry Press, Washington, D.C., 2003; ISBN 0-3090-8548-9; hardcover, $27.95.

Most of this book is a well written, informative account of the orbital outposts — space stations — launched and operated by the Soviet Union, its successor, Russia, and the United States over the past three decades. The book covers everything from the first station, the Soviet Salyut 1, launched in April 1971, to the assembly of the International Space Station, whose first elements were launched in 1998 and which is in a holding pattern until the U.S. space shuttle returns to flight.

The author sees the experience of living and working in Earth orbit as a necessary precursor to exploratory voyages to Mars and perhaps elsewhere (although he spends little time discussing such possibilities). "There is little difference between an Earth-orbiting space station and an interplanetary spacecraft," he writes.

While that may or may not be technically valid, Zimmerman does make an important point — the need to pay attention to the sociological dimensions of long-duration space flight. He recounts a few in-orbit horror stories, when conflicts led to crew members not communicating and sometimes almost coming to blows. At least one space-station mission had to be cut short because of onboard psychological problems.

Except for the 171 days in 1973 and 1974 when a trio of American crews were aboard the U.S. station Skylab, every operating space station has included at least one crew member from the former Soviet Union. Not surprisingly, then, the focus of Zimmerman's book is on the Russian-built stations and their crew members, some of whom have difficult personalities.

But Zimmerman is fairly evenhanded in describing the strengths and weaknesses of the Russian space effort in the post-Cold War period. NASA, on the other hand, gets much less sympathy. The author describes the U.S. space agency as being "made up of people more interested in protecting their jobs and building office empires than in building daring and risky spacecraft" and as being afflicted with "dry rot." He suggests that American astronauts who lived in Mir, a Russian station, were victims of "culture shock" and suffered "abandonment by NASA."

All in all, *Leaving Earth* is a good read and perhaps the best source of information on a neglected part of space history: the experience of living and working in space for days and weeks at a time, often under trying conditions. — **JOHN M. LOGSDON** *is director of the Space Policy Institute at George Washington University in Washington, D.C.*

### *Touring the Universe: A Practical Guide to Exploring the Cosmos thru 2017*

Ken Graun, 128 pages, Ken Press, Tucson, Arizona, 2002; ISBN 1-9287-7115-7; softcover, $27.95.

*Touring the Universe* is a beginner's guide to amateur observing that includes helpful information on the science of astronomy as well as a plethora of beautiful pictures.

In the first of the book's two main sections, "Armchair Tour of the Universe," Graun gives a rundown of important facts about the Sun and planets. Tables and graphic elements, including scaled images denoting the relative sizes of solar system objects, help illustrate his points.

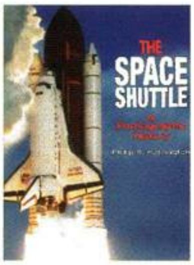
Part II, "Self-guided Tour of the Universe," concentrates on observational astronomy. Graun begins with a section on the best objects to view with the naked eye before advancing to binocular and telescopic targets. He describes what a novice should know when choosing his or her first telescope and accessories. Pictures showing available features and options are useful, as is a "Buyer Beware" section that warns shoppers away from scopes touting high magnification above all else.

Graun then moves into observational astronomy. Ten basic star maps chart objects down to 5th magnitude for every season of the year. Descriptions of the constellations and noteworthy celestial objects appear next to each map.

This section contains a couple of minor errors, including the mislabeling of a planetary nebula in M47 (it is actually in M46). Another error gives the distances of M54 and M70 as 23,400 and 25,400 light-years, respectively. These same distances were correctly assigned to M13 and M92 on the previous page.

Finally, Graun outlines how best to observe planets, deep-space objects, comets, meteors, and eclipses. Again, tables and charts complement descriptions of upcoming events, including oppositions and every eclipse through 2017 (when the next total solar eclipse will be visible from the United States). He touches on astrophotography, astronomical timekeeping, and the three types of twilight before ending with a helpful glossary and index.

*Touring the Universe* will serve as an excellent guide and a useful resource for years to come. — **DARREN DRAKE** *presents planetarium shows at the Cernan Earth and Space Center in River Grove, Illinois.*



### *The Space Shuttle: A Photographic History*

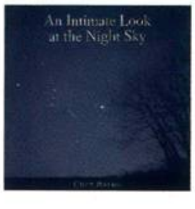
Philip S. Harrington, 88 pages, Brown-Trout Publishers, San Francisco, 2003; ISBN 0-7631-7063-1; hardcover, $19.95.

Written before the Columbia disaster, this large, image-driven book offers a more generous interpretation of the space shuttle's history than most of what has been seen in recent months. That's probably a good thing because these space "taxis" that take off like rockets and land like planes are truly feats of engineering. Harrington provides fascinating context, and while the design could be improved, the photographs are arresting and beautiful.

### *An Intimate Look at the Night Sky*

Chet Raymo, 256 pages, Walker & Co., New York, 2003; ISBN 0-8027-7670-1; softcover, $16.

While the titillating title may have had something to do with the success of this book's 2001 precursor, its poetic writing and elegant design should take most of the credit. The new paperback edition preserves these strengths, which include chapters organized by season and clear, simple sky maps. Recurring themes describe "what to see" (celestial objects) and "what to imagine" (the science behind the objects). Interwoven anecdotes on history and celestial mythology inspire readers, and appendices list when to view planets and meteor showers.



### *SETI 2020: A Roadmap for the Search for Extraterrestrial Intelligence*

Edited by Ronald D. Ekers et al., 600 pages, SETI Press, Mountain View, California, 2002; ISBN 0-9666-3353-9; softcover, $25.

Fans of *The X-Files* and serious scientists have at least one thing in common: They believe the Truth is out there. And using the plans set forth in this massive volume, SETI just may find it. Existing telescopes will be joined in the hunt for extraterrestrial intelligence by dazzling new instruments such as the Allen Telescope Array, a collection of 350 six-meter scopes spread over 2.5 acres in California, expected to become operational in 2005.

### *Uncle John's Bathroom Reader Plunges Into the Universe*

Edited by Stephanie Spadaccini et al., 494 pages, Portable Press, San Diego, 2002; ISBN 1-5714-5850-6; softcover, $16.95.

For a decidedly less sexy title, check out this compilation of interesting scientific factoids. The book covers a range of fields, including sections on ancient astronomers, martian myths, and Saturn's rings, all of which are written in a cheeky, chatty tone. Asterisks on chapters such as "Cool Astronomical Terms to Make Friends and Impress People" denote "extra-long articles suitable for an extended sitting session."

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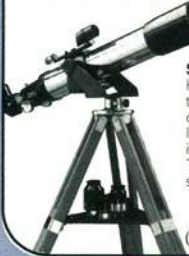

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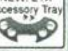

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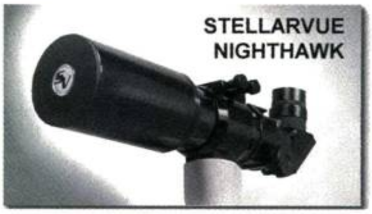

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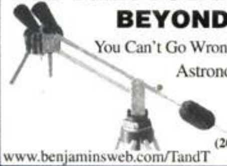

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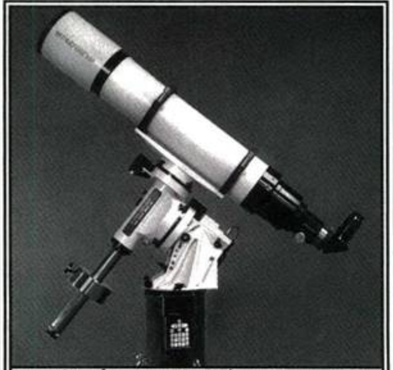

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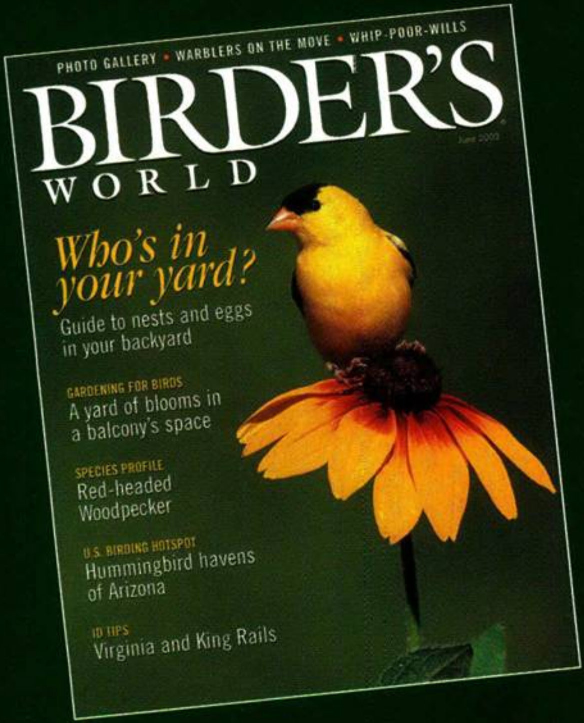

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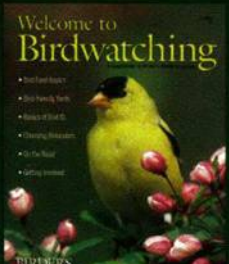

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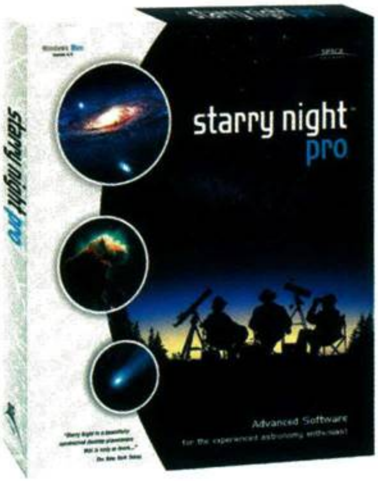
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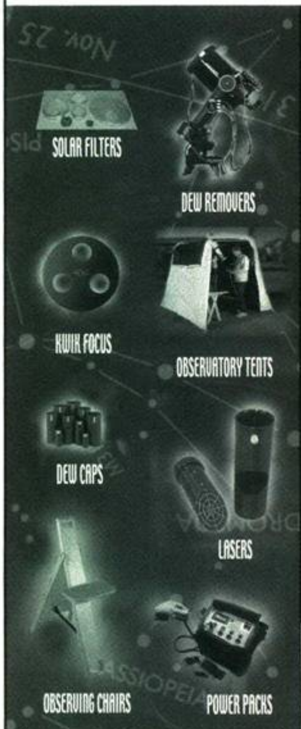

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NEXT MONTH

### Absurd universe

Cosmologist Michael Turner believes scientists understand very little about our universe, which is made up mostly of unknown forms of energy and matter.

### Belles of the ball

Plump with aged stars, globular clusters have long been the wallflowers of scientific study. But new research has rescued them from the sidelines, and now globs shine from center stage like cosmic disco balls.

### All about M33

M33, the Pinwheel Galaxy, is the farthest naked-eye object most people can see. Packed with targets, this galaxy deserves a closer look through a telescope.

### Astrophoto show

For years, two astrophotographers working on a California mountaintop have produced superb celestial images. Read about their process, but don't forget to look at the pretty pictures.

### Scope buyer's guide

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**10.11.03–10.12.03**

## The San Francisco Bay area is the setting for the Astronomical Society of the Pacific's (ASP) 115th annual meeting. The theme for this two-day event is "Cosmic Explosions." On Saturday, October 11, the weekend starts with a tour of the Stanford Linear Accelerator

**RED LIGHTS** will blaze at October star parties, as many Northern Hemisphere stargazers squeeze in one more observing weekend before the impending winter chill arrives. MARK SCHROEDER

Center. Following a members-only meeting, the ASP will host a dinner and awards ceremony at the Woodfin Suite Hotel in Emeryville. The ceremony will feature a lecture by noted comet discoverer David Levy.

The next day will feature a public symposium at Wheeler Auditorium on the University of California, Berkeley campus. Lecturers and topics include Sandra Faber on the Big Bang, Alex Filippenko on supernovae, Shri Kulkarni on gamma-ray bursts, and Kevin Zahnle on asteroid impacts.

For more information, visit the ASP's web site, www.astrosociety.org.

**09.25.03–09.28.03**

### Alberta Star Party

Eccles Ranch Observatory, Caroline, Alberta, Canada. For more information, contact Roland at 403.246.4498; e-mail, dechesne@telusplanet.net; web site, www.syz.com/rasc/asp.htm.

**09.25.03–09.28.03**

### Enchanted Skies Star Party

Socorro, New Mexico. For more information, call 505.835.0424; web site, www.socorro-nm.com/starparty.

**09.25.03–09.28.03**

### Huronia Star Party

Camp Soulaine, near Ivy, Ontario, Canada. For more information, visit www.cois.on.ca/~ssaa.

**9.27.03–09.29.03**

### Whirlpool Star Party

Doolys Hotel, Birr, County Offaly, Ireland. For more information, visit www.geocities.com/shannonsideac/whirlpol.htm.

**10.03.03**

### Far Out Friday

Adler Planetarium, Chicago. For more information, call 312.922.STAR; web site, www.adlerplanetarium.org.

**10.06.03–10.09.03**

### International Workshop on Planetary Probe Atmospheric Entry and Descent Trajectory Analysis and Science

Technical University of Lisbon, Lisbon, Portugal. For more information, visit www.sstep.org/entryws/full/index.html.

**10.16.03–10.19.03**

### ICStars Star Party

ICStars Ranch, near Warrensburg, Missouri. For more information, contact Vic or Jen Winter at 913.432.4636; e-mail, vwinter@icstars.com; web site, www.icstars.com/Ranch/starparty.

**10.17.03**

### Skywatch

Science Museum of Richmond, Richmond, Virginia. For more information, visit www.smv.org.

**10.20.03–10.22.03**

### Islamic Astronomical Conference

Amman, Jordan. For more information, e-mail odeh@jas.org.jo; web site, www.jas.org.jo/conf3.html#asp.

**10.20.03–10.22.03**

### Spacecraft Charging Technology Conference

Huntsville Marriott, Huntsville, Alabama. For more information, visit see.msfc.nasa.gov/sctc.

**10.20.03–10.22.03**

### Starry Nights Festival

Yucca Valley, California. For more information, visit www.yucca-valley.org.

**10.20.03–10.25.03**

### Twin Lakes Star Party

Pennyrile State Forest, near Land Between the Lakes, Kentucky. For more information, call 800.325.1711; web site, www.wkaa.net.

**10.22.03–10.26.03**

### Deep South Regional Stargaze

Percy Quin State Park, near McComb, Mississippi. For more information, e-mail bsimon615@aol.com; web site, www.nightskydesign.com/pas.

**10.22.03–10.25.03**

### Great Lakes Planetarium Association Conference

Cleveland Museum of Natural History, Cleveland. For more information, contact Joe DeRocher at 216.231.4600, ext. 362; e-mail, jderoche@cmnh.org.

**10.22.03–10.26.03**

### Peach State Star Gaze

White Water Express High Adventure Camp and Retreat Center, near Ducktown, Tennessee. For more information, visit personal.atl.bellsouth.net/p/o/poshedly/pssg/index.html.

**10.24.03–10.26.03**

### Amateur Telescope Meeting

Falera, Switzerland. For more information, visit www.mirasteilas.net.

**10.24.03–10.26.03**

### Blackwater Falls Astronomy Weekend

Blackwater Falls State Park, Davis, West Virginia. For more information, call 800.225.5982; web site, www.kvas.org.

**10.24.03–10.26.03**

### Custer Institute Astronomy Jamboree

Custer Institute, Southold, New York. For more information, contact Barbara Lebkuecher at 631.722.3850, Tom Carey at 631.271.2032, or George S. Lomaga at 631.298.4857.

**10.24.03–10.26.03**

### Stella-Della-Valley

Ottsville, Pennsylvania. For more information, visit www.bma2.org. ■

**CONTACT INFORMATION**

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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# RESOURCES

Learn more about this issue's topics

### GALILEO

**BOOKS** — Three recently published books tell the story of Galileo and its mission to Jupiter: *Mission Jupiter: The Spectacular Journey of the Galileo Spacecraft* by Daniel Fischer (Copernicus Books, New York, 2001); *Jupiter Odyssey: The Story of NASA's Galileo Mission* by David M. Harland (Springer, New York, 2000); *The Worlds of Galileo: The Inside Story of NASA's Mission to Jupiter* by Michael Hanlon with a foreword by Arthur C. Clarke, (St. Martin's Press, New York, 2001).

**WEB** — The ultimate source for information about the Galileo spacecraft and the results it obtained at Jupiter is NASA's excellent web site, galileo.jpl.nasa.gov.

### ORION NEBULA

**BOOKS** — This month, a general-audience book is due out from one of the preeminent researchers on the Great Nebula in Orion, C. Robert O'Dell. Aptly titled *The Orion Nebula: Where Stars Are Born* (Harvard University Press, Cambridge, Massachusetts, 2003), it should provide everything you want to know about this celestial jewel.

**WEB** — The National Radio Astronomy Observatory's Green Bank Telescope page offers an excellent tour of the nebula in various wavelengths of light. Check out www.gb.nrao.edu/~rmaddale/Education/OrionTourCenter/index.htm for views in optical, infrared, and radio wavelengths.

### DAVID HELFAND

**ARTICLES** — Learn more about the purported "quark star" 3C 58 in David Helfand's recent article, "Way too cool" (*Astronomy*, March 2003). A couple of his many scientific papers include the invited essay "High-Energy Astronomy: 60 New Octaves of Discovery Space" (*Publications of the Astronomical Society of the Pacific*, v. 113, p. 1159, 2001) and "The FIRST Unbiased Survey for Radio Stars" (David Helfand et al., *The Astronomical Journal*, v. 117, p. 1568, 1999).

**WEB** — David Helfand's home page is www.astro.columbia.edu/~djh/research.html. Check out a RealAudio clip from an appearance on the PBS program *The NewsHour*, where he discussed a bright gamma-ray burst from December 1997, at www.pbs.org/newshour/bb/science/jan-june98/bang_5-7.html. To find out more about his VLA radio survey, (FIRST), go to sundog.stsci.edu. For an example of the nontraditional techniques Helfand uses to convey physics concepts, see his take on Beethoven's Ninth Symphony at www.ccnmtl.columbia.edu/projects/helfand.

### TUCANA AND HYDRUS

**BOOKS** — If you're new to observing or are unfamiliar with the southern sky, pick up a copy of *The Southern Sky Guide*, 2nd edition, by David Ellyard and Wil Tirion (Cambridge University Press, New York, 2001). Written for beginners, the book includes an introduction about observing and objects visible from the Southern Hemisphere. The book's second half features two full-sky charts for each month.

Another reference for deep-sky observing south of the equator is *The Southern Sky: A practical guide to astronomy* by David Reidy and Ken Wallace (Allen & Unwin, Boston, 1987). The book covers a variety of topics from naked-eye observing to telescope accessories and astrophotography. At the end, the authors highlight 103 deep-sky objects with photographs and descriptions of each.

### MOON OBSERVER'S NOTEBOOK

**BOOKS** — A beautiful and detailed lunar atlas, Antonín Rükl's *Atlas of the Moon* (Kalmbach Publishing Co., Waukesha, Wisconsin, 1992) is an essential resource. *Observing the Moon* by Gerald North (Cambridge University Press, New York, 2000) gives a descriptive tour of Earth's satellite. For photos of the Moon through an entire lunation and close-up shots of major features, check out *Photographic Atlas of the Moon* by S. M. Chong, Albert C. H. Lim, and P. S. Ang, (Cambridge University Press, New York, 2002).

**WEB** — The Consolidated Lunar Atlas site contains scans of the best Earth-based lunar photography. Check it out at www.lpi.usra.edu/research/cla/. An on-line version of David Bowker and J. Kenrick Hughes's *Lunar Orbiter Photographic Atlas of the Moon*, published by NASA in 1971 but long out-of-print, is available at www.lpi.usra.edu/research/lunar_orbiter/index.html.

### STARS ON THE STARS

**BOOKS** — The amateur astronomers featured in the article keep up to date with Internet searches, *Astronomy* magazine subscriptions, and a little night (sky) reading. Robert Smith recommends *Wrinkles in Time* by George Smoot and Keay Davidson (W. Morrow, New York, 1993) for its coverage of background radiation, black holes, and time warps. Tim Russ cites *Nightwatch*, 3rd edition, by Terence Dickinson (Firefly Books, Ltd., New York, 1998) as a good book for people starting out. Gordon Clapp suggests *Seeing in the Dark* by Timothy Ferris (Simon & Schuster, New York, 2002). Chris Bruno loves *Cosmos* by Carl Sagan (Random House, New York, 1980) for its extensive coverage of the universe's functions.

### ASTROPHOTOGRAPHY

**BOOKS** — For a good, overall discussion of equipment and techniques, as well as much more about every aspect of amateur astronomy, read *High Resolution Astrophotography* by Jean Dragesco (Cambridge University Press, New York, 1995). Yet another excellent book on the topic is Michael A. Covington's *Astrophotography for the Amateur* (Cambridge University Press, New York, 1999).

**WEB** — Internet sites related to astrophotography abound. A good, basic introduction to black-and-white film astrophotography is Martin Germano's web site at home.earthlink.net/~mcgermano.

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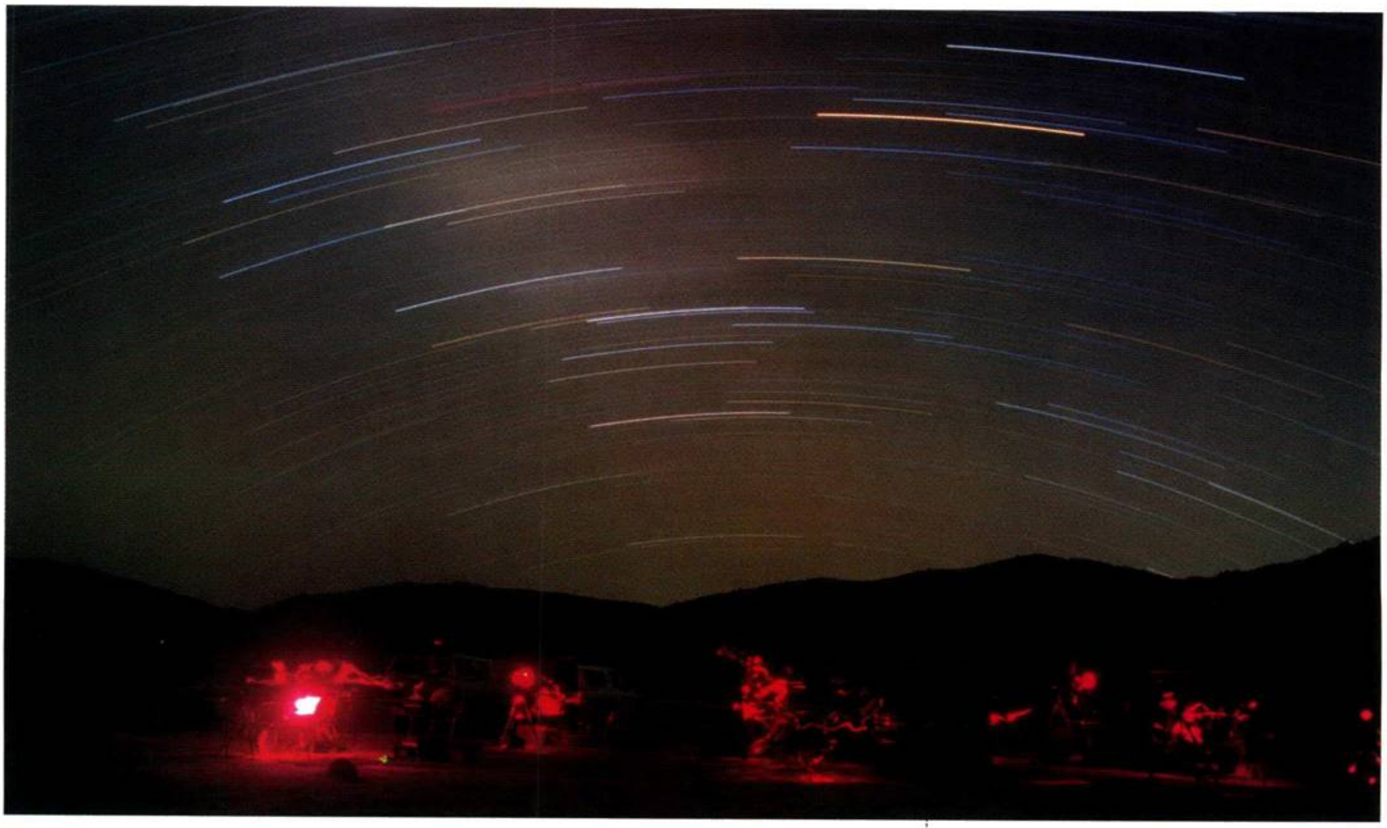
# Reader gallery

## Readers share their images . . .

Star party /// Planetary nebula /// Mars sequence /// A pair of galaxies
Sunspot group /// Lagoon and Trifid nebulae

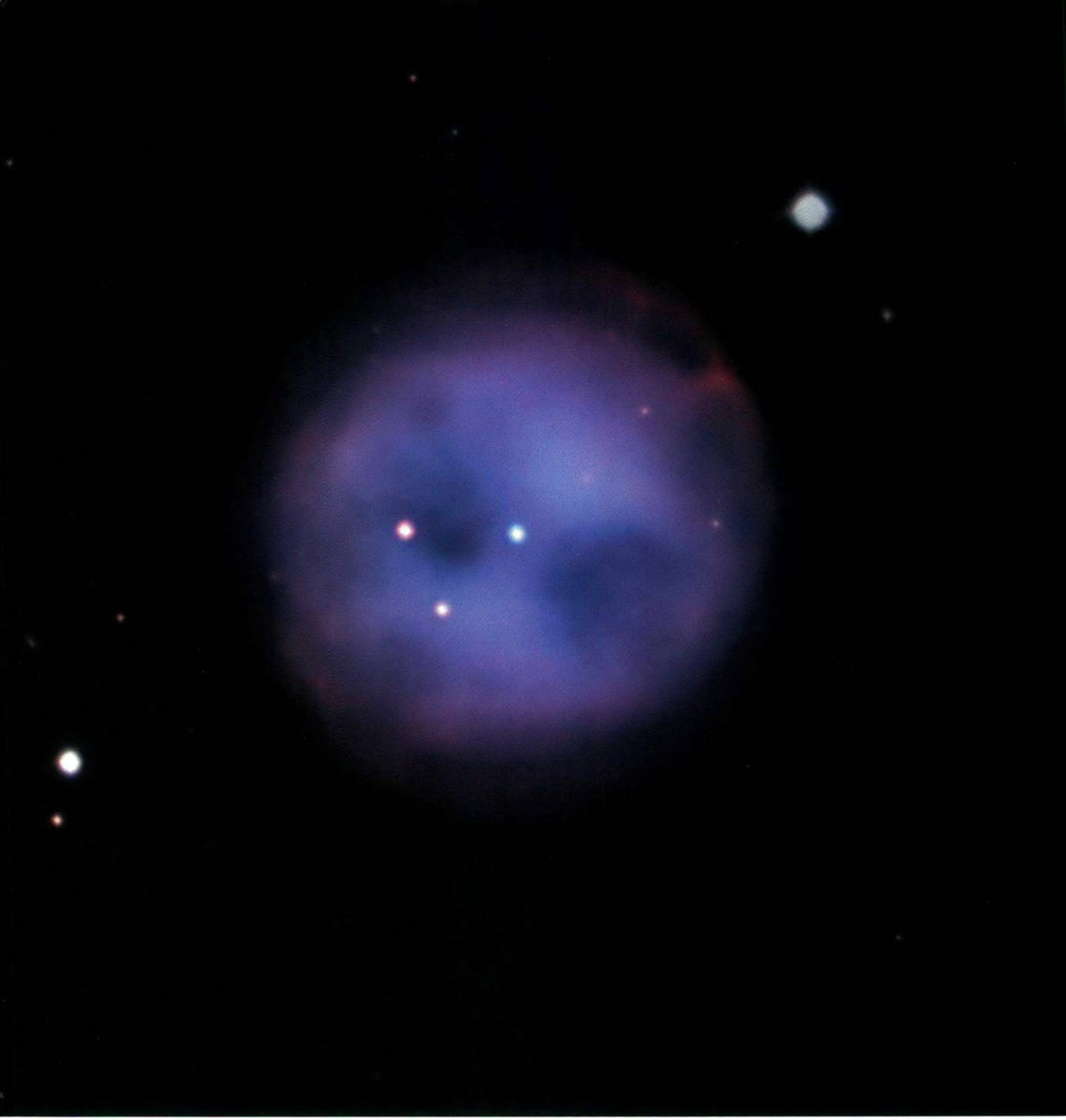


*Above,* **THE ANZA-BORREGO STAR PARTY** [24mm lens at f/4, Kodak Ektachrome E200 film, 1 hour 25-minute exposure taken April 14, 2002, at the Anza-Borrego Desert State Park, California] /// **CHRIS COOK**

**THE SOCIAL ASTRONOMER**

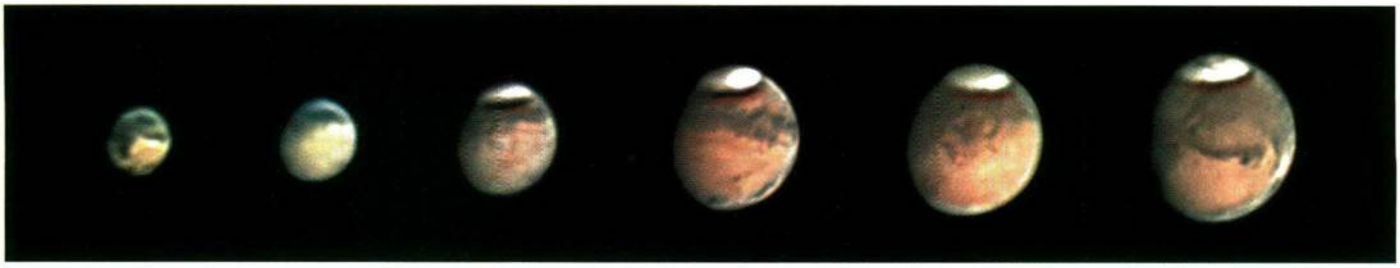
### Star party

Most amateur astronomers are, by nature, social animals. They love to congregate in groups and share the beauty of the night sky. This time exposure photograph shows stars over the southern horizon leaving brilliant trails. The camera was placed on a sturdy tripod, and its shutter was left open for 85 minutes. During that time, Earth's rotation carried the camera through space, creating the trails. The part of the sky that looks cloudy is the Milky Way. Beneath the sky and in front of the background hills, amateur astronomers move about with the help of red flashlights. Red is used because the human eye is least sensitive to red light.



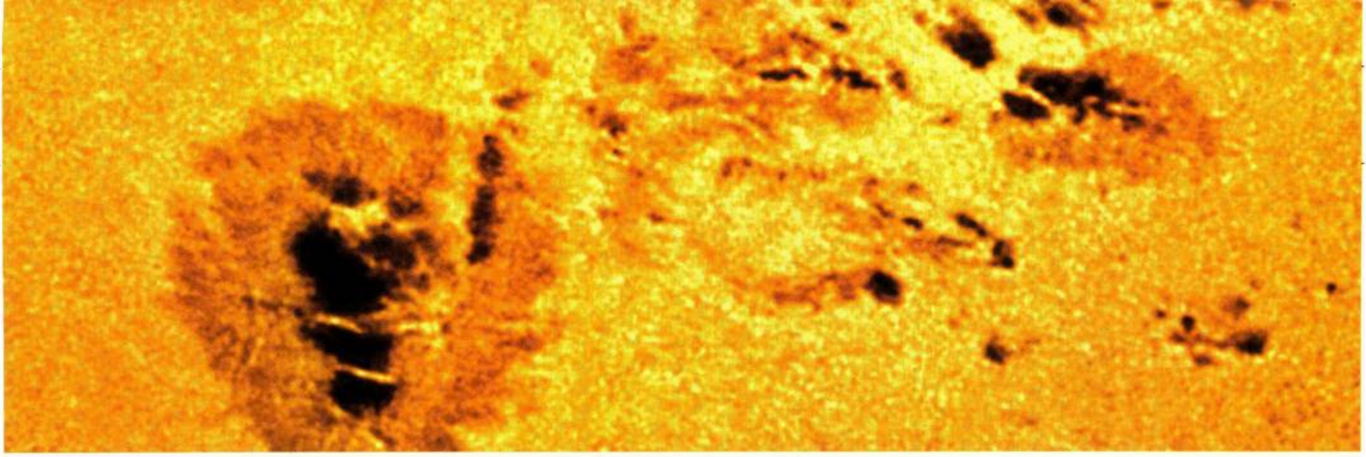
*Above,* **THE OWL NEBULA (M97) IN URSA MAJOR** (20-inch home-built Newtonian reflector at f/4, Finger Lakes Instruments IMG6303E CCD camera, LRGB image with exposures of 90, 24, 24, and 30 minutes, respectively, taken April 12, 2002) /// **BRIAN LULA**

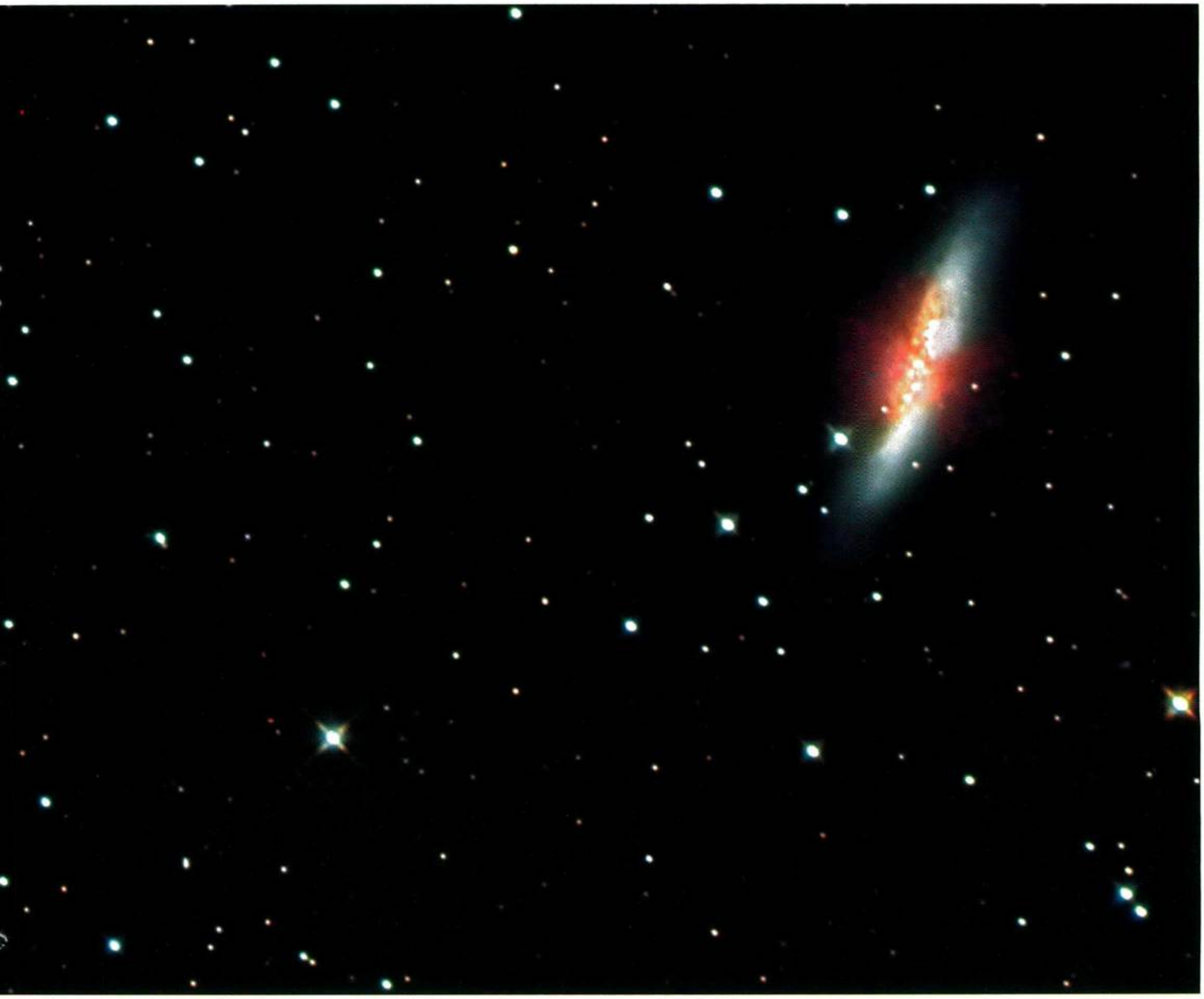
Send photos to: ASTRONOMY Reader Gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.



*Top sequence,* **MARS IN 2003** (16-inch Newtonian reflector, ST9XE CCD camera, eyepiece projection yielding f/55.4: **[1]** March 8, LRGB = 24 seconds total exposure; **[2]** March 30, LRGB = 19 seconds total; **[3]** May 4, RGB = 23 seconds total; **[4]** June 1, RGB = 22 seconds total; **[5]** June 13, RGB = 13 seconds total; **[6]** June 24, RGB = 12 seconds total.) /// **DONALD C. PARKER**

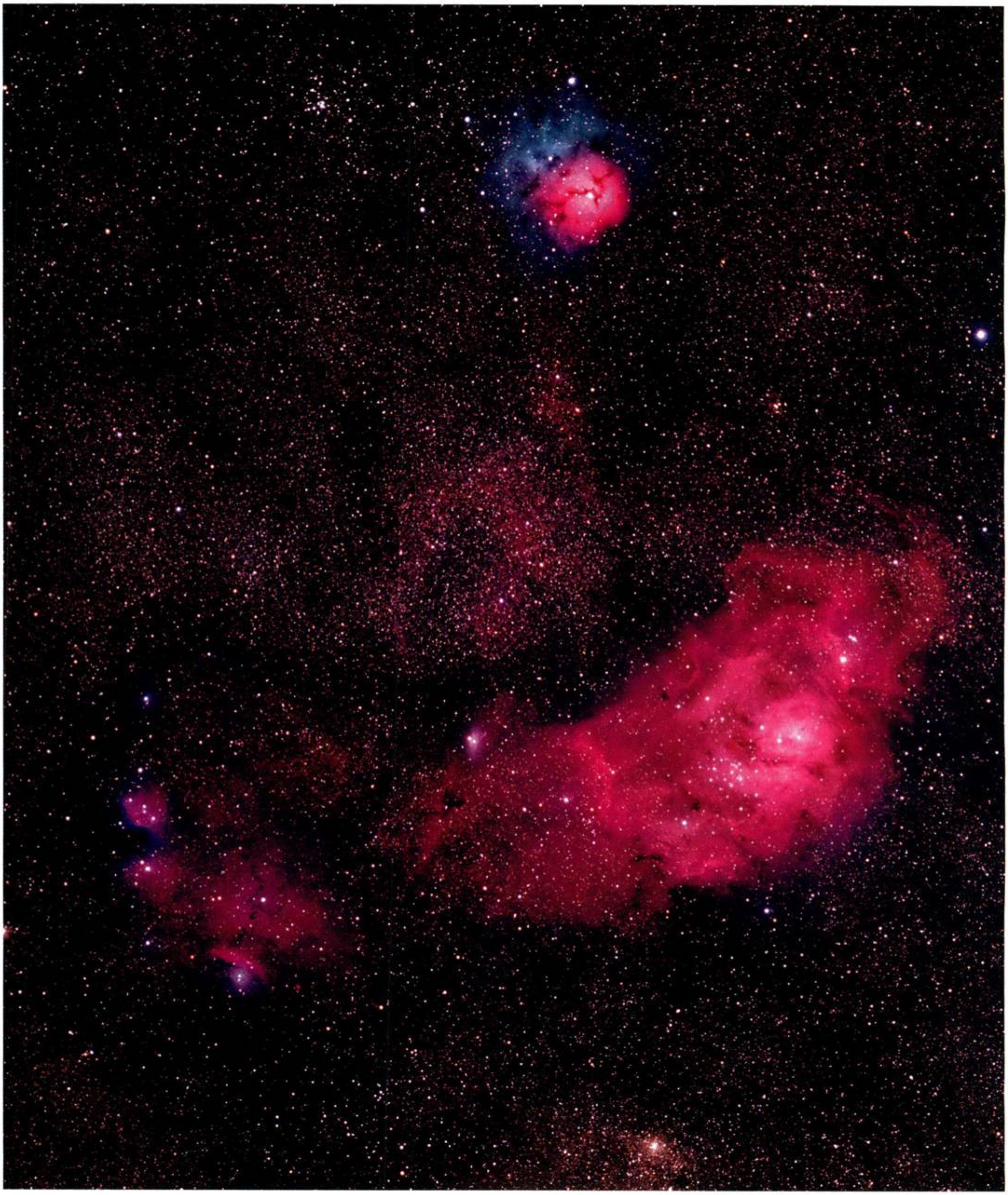
*Bottom,* **GALAXIES M81 AND M82 IN URSA MAJOR** (Takahashi Epsilon 2100 f/3 Astrograph, SBIG ST2000XM CCD camera, LRGB image of 35, 15, 15, and 15 minutes, respectively) /// **RICHARD JACOBS**





*Top.* **AN ACTIVE SUNSPOT REGION** (6-inch Sky-Watcher apochromatic refractor, Herschel wedge, Sony TRV 740E videocamera, taken June 16, 2003, from Witten, Netherlands) /// **RALF VANDEBERGH**

*Below,* **THE LAGOON AND TRIFID NEBULAE, M8 AND M20** (Astro-Physics 6-inch f/7 EDF refractor, digital composite of three 30-minute exposures on hypered 120 format Kodak PPF Pro 400 film) /// **GEORGE GREANEY**



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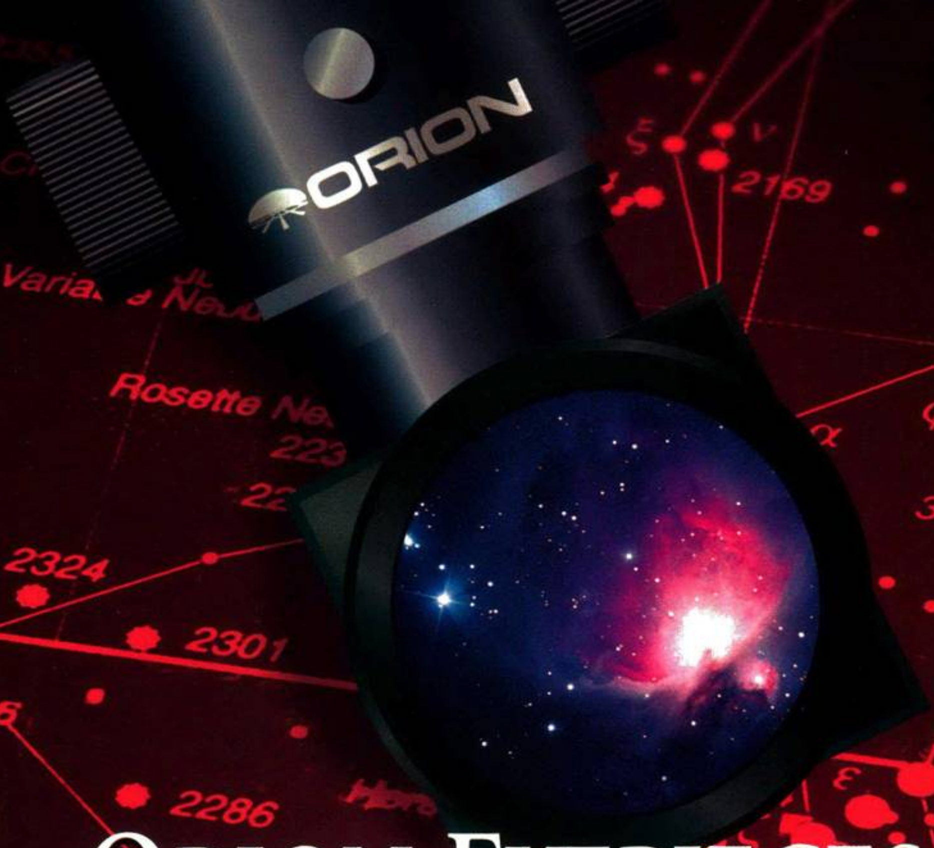

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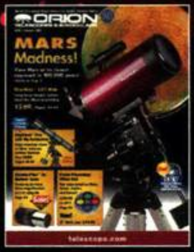

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